Harbor Rock
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April 3, 2000

Mr. Daniel A. Coleman, J.D.
Maryland Port administration
Office of Procurement, 2nd Floor, Suite 260
Maritime Center II
2310 Broening Highway
Baltimore, MD 21224-6621

Reference: Solicitation Reference No. 200010-S
Innovative Use of Dredged Material

Dear Mr. Coleman;

It is with great pleasure that HarborRock provides this response to the referenced solicitation. We are very proud of the beneficial reuse capabilities of HarborRock and are encouraged by the prospect of sharing these same capabilities with the MPA.

Thank you for providing us this opportunity. Please treat our entire submittal to the solicitation confidential.

Sincerely,

J. B. Otto

Jeffrey B. Otto
President

From: Eldon Miller
Subject: Innovative Uses of Dredged Materials Solicitation # 200010-S

As I began my review of the HarborRock proposal, I noted the following sentence on pg.8, (last paragraph):
"The HarborRock method to produce LWA (lightweight aggregate) from dredge material was based on extensive work done over the past two to three years by the consulting engineering firm, E Solutions, in partnership with the Enron Corporation. E Solutions formed HarborRock to market the technology developed."
I do not know whether these references to Enron are to the parent corporation or to Enron North America, a subsidiary, or to some other subsidiary.

I have scanned the remainder of the proposal to determine the extent of the ties to Enron.
--- one of the principals of HarborRock is a former Director of Enron North Amrerica,
--- other referrences to Enron are all historical in the context of the sentence quoted above.
--- Enron is not bidder, subsidiary, joint venture partner, or any other way that I can determine, connected or related to this current procurement.

As you know, I have a long standing commitment to this procurement and want to do everything possible to see that the best possible decisions are made in the future development of innovative uses of dredged material. I need, however to acknowledge that I

RESPONSE TO REQUEST FOR PROPOSAL # 200010-S

INNOVATIVE USE OF DREDGE MATERIALS

Submitted by

HarborRock

to the
Maryland Port Administration

Harbor Rock

Company name: HarborRock
Solicitation reference No.: 200010-S
Due date: April 3, 2000

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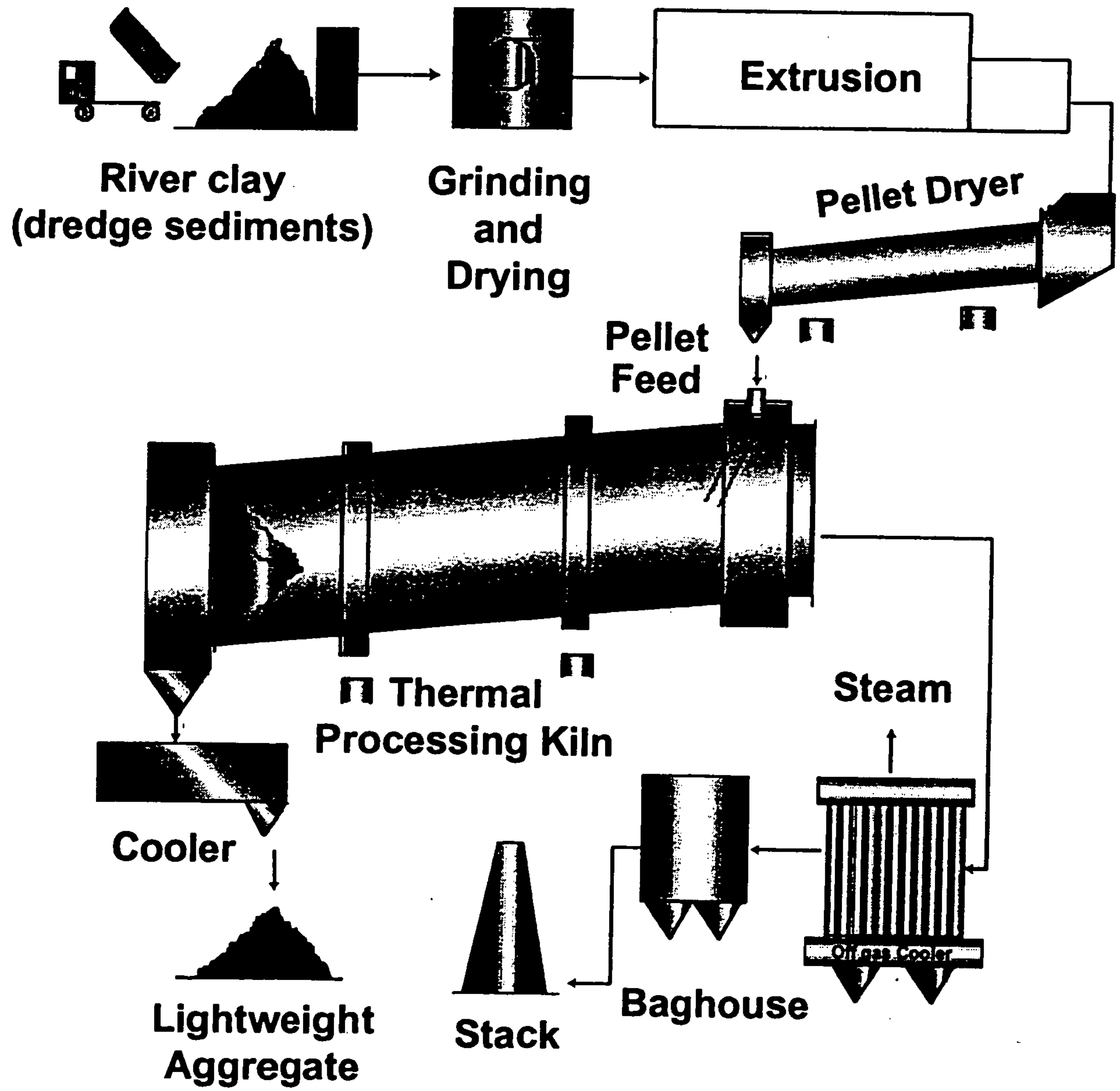
HarborRock General Process Description

River clay (mined sediments), are received on a tip floor via a loader or conveyor. The clay material is screened, dried, ground, and extruded into pellets. The green pellets are dried, then fed into a rotary kiln and fired. The lightweight aggregate is then cooled, graded and shipped to the end users.



Phase 1 – Technical Evaluation and Bench Scale Testing

(Nominally 20 KG finished product)

Technical Approach – Section 2.2.2.2

Background on HarborRock

HarborRock has been formed to develop and manage projects that recycle and convert estuarine sediments into a lightweight aggregate. The purpose of the Company's presence and development is to recycle earth resources and provide a safe, cost-effective and permanent decontamination disposal solution to large volumes of dredged estuarine sediments removed from the aquatic ecosystem.

Dredged sediments are in certain limited instances currently being beneficially reused. Habitat improvements including creating, enhancing and restoring wetlands have been successfully used in the past. Although it has had limited applications, their beneficial impact to the environment and our society has been well documented. Unfortunately, it is a limited disposal option. HarborRock's proprietary process for the beneficial reuse and conversion of estuarine sediments into lightweight aggregate (LWA) realizes the full benefits of the beneficial reuse approach without the current limitations of suitable applications, sites, and volumes.

HarborRock's beneficial reuse approach to dredged river clay disposal is based upon the controlled production of a range of aggregates, from common dense aggregate to a high quality lightweight aggregate. Lightweight aggregate production is a viable long-term business opportunity due to an existing market imbalance whereby projected demand for lightweight aggregate is nearly double the current market supply. This market imbalance is the result of current shale-based aggregate production being antiquated, energy intensive, highly pollutive and inefficient. Since current production is located near shale deposits and not metropolitan areas where the demand is located, trucking distances add a significant cost to the product. HarborRock plants are built at the source of the raw material, along the waterfront on sites that have access to rail and truck and are in close proximity to the marketplace.

In contrast to current lightweight aggregate manufacturing, with its characteristics of unpredictable crush strength and natural impurities, HarborRock's aggregate is a highly engineered product. HarborRock's process screens the dredge material to remove unusable debris, then dries, grinds, and extrudes the material into pellets. These pellets are then placed into a thermal processing kiln that operates at temperatures over 2,000° F. The result is a predictable end product that has the properties of greater strength; yet lighter weight than the current aggregate on the market. Since HarborRock's production facilities are state-of-the-art, they meet all existing air emissions standards and consume less energy than current production facilities.

HarborRock's beneficial reuse and conversion of estuarine sediments into a range of aggregates, including lightweight, creates a permanent disposal solution, which is cost predictable and cost competitive with alternative options. The HarborRock process is attractive to the U.S. Army Corp of Engineers, Port Authorities and private dredging concerns because it is able to process large volumes of sediment materials, with plant sizes ranging from 250,000 CY/year to over 2,000,000 CY/year. The plant size is determined by factors such as the quantity of raw materials available; the supply frequency of new material; and raw material storage capacity. The HarborRock approach also eliminates periodic reauthorization of disposal monies and the repetitive development and permitting of sites.

The environmental community is also highly favorable toward HarborRock's approach. The beneficial reuse approach reduces the need for CAD and CDF disposal options. HarborRock's state-of-the-art process effectively destroys organic compounds, is routinely and accurately monitored and the end product easily passes TCLP tests. Valuable real estate can now be beneficially used and enjoyed by our society, rather than converted into disposal sites.

HarborRock is able to perform pilot scale testing on dredged sediments in its strategic partner, Svedala Industries' Research & Development facility located in Oak Creek, Wisconsin. This facility is able to monitor all process variables and demonstrate the effectiveness of the HarborRock process in using the local sediments, either clean or unsuitable, to produce a range of aggregates, including high quality lightweight aggregate. The aggregate produced is also tested to ensure that it meets all ASTM and other applicable standards for LWA and passes all applicable environmental regulations.

Treatment Process Effectiveness – Section 2.2.2.2.1

HarborRock has conducted bench scale tests on sediments obtained from the Ports of Wilmington, DE; New Jersey/New York; San Francisco; and Seattle. **A copy of the Seattle report is found in Attachment 1.** These tests have shown that the lightweight aggregate produced is of very high quality and will meet ASTM standards for LWA and that the LWA passed TCLP tests for metals.

There are over thirty (30) companies, operating over 44 rotary kilns, in the United States producing lightweight aggregate. These companies fire naturally occurring clay, shale or slate to produce their products. The industry's trade association is called The Expanded Shale, Clay and Slate Institute (ESCSI). The HarborRock process is a proprietary method that enables it to reuse sediments in lieu of mined resources to produce its LWA.

The effective use of rotary kilns for the processing of contaminated soils is well documented by the EPA, the US ACOE and industry. **Attachment 2** is a client reference list provided by our strategic partner and kiln supplier, Svedala Industries, Inc that documents the numerous kilns they have supplied for this purpose. Due to the known destruction efficiencies obtained in rotary kilns, numerous companies in the cement and asphalt industries process hazardous wastes in their kilns as a source of additional revenue.

Rotary kilns and auxiliary air pollution control equipment operate at temperatures sufficient to achieve 99.99% or greater destruction efficiency of organic compounds. Metals typically found in sediments are bound within the mineral matrix of the LWA produced. TCLP tests performed by HarborRock on LWA made from sediments containing metals easily passed RCRA standards.

Project Specific Applicability (Section 2.2.2.2.2.)

The HarborRock process is capable of using either clean or unsuitable sediments without sacrificing product quality. The air pollution control system for the plant will be designed to treat and control the emissions that may result from processing sediments that contain organic and inorganic contaminants. The system design, as shown in the attached Process Flow Diagram, **(Attachment 3, page 6)** destroys organic compounds using two methods. The first method exposes organic compounds to a temperature of about 2,000°F in the kiln. This high temperature volatilizes and destroys most organic compounds.

The second method of control offers further assurance of organic contamination destruction. The off-gases from the kiln, which may contain organic compounds, are routed to an after-burner. In the after burner, the gas stream is heated to a temperature of approximately 2,200° F for a retention time sufficient to achieve the desired degree of destruction efficiency, generally 99.99% destruction. The retention time and operating temperature is based on EPA guidelines for the destruction efficiency required.

The manufacture of LWA results in about 4% of the processed feedstock material being captured as a particulate in the baghouse. The use of extruders in the HarborRock process, to make the feed pellets that are fired in the kiln, allows baghouse dust material to be recycled.

Metals from the sediments are either captured in the air pollution control system, i.e. the baghouse, or are entrained in the aggregate. Material captured in the baghouse will be analyzed to determine contaminant concentrations and recycled into feed pellets if found to be reusable. If the concentration of metals in the baghouse ash dictate disposal, then it will be taken to a properly permitted landfill.

The aggregate will be routinely TCLP tested to ensure that meets all standards for use in concrete mixes, masonry blocks, road asphalt or any other applications that use aggregate.

Attachment 1 contains TCLP tests performed by HarborRock on bench scale LWA samples made from material from the Puget Sound, WA. These results show the metals concentration to be well below RCRA limits.

Waste Stream Generation.

The only potential source of waste material in the HarborRock process is what is contained in the sediments. The HarborRock process does not use, or require, any additives or chemicals to manufacture aggregates from sediments.

After collection of material from the containment cell, the next step used in the process is to screen out of any material in the dredge sediments that this larger than 40 mesh. This is typically large stones, shells or obvious rubbish. Rubbish is disposed of in a landfill. The stones and shells screened from the process will be washed and sold to potential users.

Potential Beneficial Use of End Products or End Uses (Section 2.2.2.2.3)

As discussed in Section 1.3.8, a major objective of this RFP is to identify a process that produces one or more products that have an identified and proven market. The production of a range of engineered aggregates clearly meets this objective.

The HarborRock process is designed to engineer a controllable range of aggregates with varying density and strength characteristics to meet specific engineering specifications, market conditions, and pricing constraints.

The highest market value aggregate produced by the HarborRock process is lightweight aggregate (LWA). As discussed in the attached **HarborRock Business Outline, Attachment 4,** LWA is a valuable building material in great demand today in a number of different applications. These applications include geotechnical fill; structural grade concrete, masonry blocks, and road asphalt.

LWA typically weighs up to 40% less than dense aggregate making it the engineering choice in high-rise buildings, bridge decks and masonry blocks. Its lighter weight also makes it economical to transport, reduces the need for extensive foundations, speeds erection and allows for the use of smaller, more economical equipment.
In bridge decks the reduced weight allows less reinforcing and structural steel, less seismic bracing and longer spans.

In road surface applications, the freeze-thaw durability of lightweight aggregate makes it extremely durable. Additionally, the higher skid resistance of LWA produces a safer road surface because it resists polishing, unlike dense aggregate. Under wear, fresh LWA interior cells with rough ceramic-like edges are continually exposed. Lightweight aggregate also reduces material haul costs. LWA weighs up to about 40% less than dense aggregate, allowing for a much larger volume of material per truckload and less overall tonnage to be hauled.

Similar economies can be gained by LWA in masonry block applications. A block that weighs more than 37 ponds requires a two-man crew to install. A typical 16" block made from heavy weight aggregate weighs 37 lbs. A 24" block made using LWA weighs less than 35 pounds. Studies have documented a 65% increase in productivity by using a longer block length and fewer bead joints. Increased productivity will result in significant labor savings.

There are currently thirty (30) companies that make LWA by expanding clay or shale. In general, as discussed in the attached presentation material, there is not enough LWA produced to meet the growing market demand for the product. The US Geologic Survey has reported a serious concem over the availability of aggregates in the Baltimore-Washington corridor. (Please refer to **Attachment 5).** The causes for the concem are competing land uses and the desire not to have quarries near urban areas. Moving the source of aggregates further from its point of use will result in higher haul costs, increased infrastructure burden and increased levels of emissions from transport vehicles.

Please see **Attachment 6** for copies of literature published by the Expanded Shale, Clay and Slate Institute (ESCSI), the trade association for the LWA industry.

<u>Environmental Effects (Section 2.2.2.2.4)</u>

HarborRock uses natural gas in the calciner and the kiln to manufacture the aggregate. Natural gas may also be required in the air pollution control system to ensure complete destruction of organic compounds that may be present in the sediments.

The full-scale plant will meet the recently promulgated EPA Maximum Achievable Control Technology (MACT) standards for lightweight aggregate kilns and all other applicable air emissions regulations in effect for the area.

A positive environmental effect resulting from the HarborRock process is the reduction in truck emissions that result from not having to haul aggregates into the area from outside the region. For example, currently the local market for LWA is being supplied from plants operating in the states of Maryland, New York, Virginia, and North Carolina. Avoiding the necessity to haul in aggregate from great distances will help reduce highway maintenance costs, and lessen the infrastructure burden and negative environmental impacts.

<u>Treatment System – Overview (Section 2.2.2.2.5)</u>

The HarborRock method to produce LWA from dredge material was based on extensive test work done over the past two to three years by the consulting engineering firm, E Solutions, in partnership with the Enron Corporation. E Solutions formed HarborRock to market the technology developed. E Solutions contracted with the Fuller

Company to perform development work on manufacturing LWA from dredge materials. E Solutions is the sole owner of the information learned to date.

The idea to produce aggregates from sediments is well known and was patented in the 1980's, however that patent has expired. HarborRock considers its process proprietary. HarborRock has performed extensive testing, at considerable expense, to create the current process flowsheet. This flowsheet, by introducing significant pre and post engineering processes into the pyrokiln operation, represents a significant improvement to the methods currently used to produce LWA.

Process Description (Section 2.2.2.2.6)

The flow chart showing the HarborRock treatment process is found in simplified form in the attached HarborRock Business Outline, **Attachment 4** material and in expanded detail in the generic Pilot Kiln Test Program **(Attachment 3)** material.

The untreated sediments would be mined from the containment cell using conventional mining equipment. This equipment could be buckets with draglines or walker type loaders suitable for slurries or solid matter. The material would be placed into a feed hopper, which discharges onto a conveyor. The conveyor will move the material to the receiving area. The harvesting of the material from the containment cell would be conducted in a manner that facilitates natural dewatering and provides the less expense method for placement of new material.

(Referencing Amendments #4 & #7, Question/Answer 18, HarborRock would like to be considered for the operation of the containment facility. Being directly responsible for the operation of the facility will ensure that it is operated in a manner that best meets the material handling needs of HarborRock, minimizes cost, and facilitates dewatering and crust management. In all locations HarborRock is currently developing, it has undertaken the responsibility for the containment facility for the reasons outlined above.)

In the receiving area, the sediment material will be screened to remove any unwanted materials, then dewatered using mechanical and thermal dewatering equipment, such as belt or screw presses. The design criteria for the type and extent of dewatering equipment to be used will be based on having to dewater a slurry. The water effluent would discharge into holding tanks where it would be allowed to settle, treated as required to meet code, then discharged either back to the river or treatment works as determined by the permitting agencies.

The dewatered sediments, resembling cake, will be feed into a combined grinding and thermal drying operation designed to grind the sediments down to a fine powder with a consistency of at least 100 mesh. The purpose of this step is to ensure uniform grain size of the feedstock material. The heat that is used in this step is recovered from the aggregate cooler. This operation is conducted at a minimal temperature in order to stay well below the volatilization point for possible contaminants that may be present in the sediments.

The material is then feed into a conditioning chamber to render the material mineralogical inert by subjecting it to a high temperature atmosphere. This step is only performed if the product to be produced is a high quality lightweight aggregate that requires controlled chemistry to produce. When the plant is producing dense aggregate, the chemical composition of the feedstock, such as the oxides, is not as critical as when making LWA.

After conditioning, the material is cooled, and then mixed with about 20% water in a paddle mixer to get the consistency needed for extruding the material into pellets. The moist material is run through an extruder that pushes the material through a die plate containing holes approximately ½ inch in diameter. As the material is pushed through the holes it is cut to a length of about 1 inch, thus forming a ½ inch diameter pellet one inch long. These pellets are then fed directly into the kiln for firing or routed into a pellet drier. The pellets are dried to the degree necessary to make them less susceptible to breakage and are stored for processing in the kiln later.

The extruded pellets are fed into the kiln for firing. The temperature in the kiln reaches about 1,800° F. When the pellets reach that temperature they undergo a volume expansion and bloat to about 1.3 times their original size. This expansion in size reduces the density and thus gives the aggregate its lightweight.

The hot aggregate exits the kiln onto the aggregate cooler for cooling. Heat from the cooler is recycled and used throughout the process.

The cooled LWA is stockpiled, graded to meet customer's size requirements and shipped as required.

Environmental, Health and Safety Concerns (Section 2.2.2.2.7)

The occupational health and safety issues related to the full scale system are concerns normally associated with any industrial process that has rotating equipment, high temperature applications, and feedstock material that is potentially contaminated.

The system will be designed so that all sediments clean or contaminated, and residuals never come in contact with humans or the environment. The HarborRock process has been designed to ensure complete containment of the materials during processing.

Operators in a secure control room will control the entire kiln process, air pollution control system, and all other health or environmental systems. The processes will be designed failsafe so that in the event of a failure, without operator action, the systems will shut down in a safe mode.

A significant factor in the permitting and operation of this system are the air emissions generated by the combustion of natural gas. In order to minimize emissions, the best possible burners will be used and the most advanced pollution control devices.

The most significant noise generation comes from the aggregate crushing and sizing operation. It is anticipated that this step will only be performed during the dayshift if noise is a factor to the neighbors.

Quality Assurance (Section 2.2.2.2.8)

The bench scale and pilot scale tests will be performed under the supervision of HarborRock at the research and development facility owned and operated by our strategic partner Svedala Industries. The Svedala Process Research &Test Center conducts test programs for a broad range of customers and applications and is well suited to conduct tests of this type. A list of clients who have had test programs performed by Svedala is shown on **Attachment 2.**

HarborRock intends to write and implement its own QA/QC Plan for the full-scale plant based in part on the information learned about the performance of the system from the pilot scale test.

Organizational Experience, Personnel and Facilities (Section 2.2.2.3)

Organizational Experience (Section 2.2.2.3.1)

Please see **Attachment 9** for the Experience Questionnaire

HarborRock was formed in 1998 to exclusively develop projects that recycle clean or contaminated dredge sediments into lightweight aggregate. Prior to forming HarborRock, Jeffrey Otto, owner of E Solutions, a consulting engineering firm, began evaluating the production of aggregate from dredge materials in 1995.

The company's knowledge expanded with Mr. Otto's efforts, in conjunction with the Enron Corporation, to development a full-scale treatment facility to serve the dredge disposal needs of the New York/New Jersey Harbor and other ports in the United States. This development effort resulted in a thorough understanding of all the early stage decontamination technologies under development and their limitations. It also resulted in understanding the economic forces behind dredging and dredge material disposal; the costs and benefits of using dredge material to produce a practical and high value end use product; and an in-depth understanding of the uses and market potential for a range of aggregates, including lightweight aggregate.

This knowledge base was augmented by interviewing port authority officials, regulatory agency personnel and by producing lightweight aggregate from dredge materials obtained from the Ports of Seattle, San Francisco, Philadelphia/Wilmington, DE, and New Jersey/New York.

Boeing, which represented over $100 million in annual revenue to the company. He also successfully recruited LaClede Steel, Metro Machine and other new large industrial accounts to the region while in the Economic Development Department. He was also a founding member in the then newly formed wholesale electricity trading division where he developed new wholesale trading accounts for the company nationwide.

Mr. Otto left the utility to manage the development and construction of a $200 million greenfield recycled papermill in New York City, the first industrial project developed in New York City in over 50 years.

Mr. Otto started E Solutions Inc., a consulting engineering firm that specializes in energy, environmental and industrial project development. Clients of E Solutions have included Con Edison, Visy Paper and Enron Corporation.

Most recently he formed HarborRock to develop projects nationwide that recycle dredged materials into lightweight aggregate.

Mr. Otto has served as the Chairman on national American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) technical committees and on the boards of numerous civic organizations.

Mr. Kimbrough

Executive Vice President- Strategic Planning for HarborRock Holdings. Mr. Kimbrough has 20 years experience in management consulting to industry in the areas of organizational structure, compensation, strategic planning and finance.

Mr. Kimbrough's educational background includes a law degree from Rutgers University Law School and a Bachelors degree in Accounting from Michigan State University. He also earned his CPA while employed with Touche Ross as a Tax Manager.

Upon graduating from MSU, Mr. Kimbrough began his career in the Controller's office of Ford Motor Company in Sterling Heights, Michigan where he gained experience in cost accounting and financial analysis. After earning his law degree, Mr. Kimbrough was recruited by the public accounting firm of Touche Ross and gained his first experience in business consulting and strategic planning.

After earning his professional accounting certification, Mr. Kimbrough began his management consulting career with Sibson & Company as a senior consultant, working with a number of Fortune 500 companies in the areas of strategic planning and executive compensation consulting.

Mr. Kimbrough left Sibson & Company to join M Financial in 1986 where he has spent the balance of his career. While at M Financial, Mr. Kimbrough has worked at three

COVER SHEET

FAX

To: BIG E (ELDON)

Fax #:

From: BILL

Subject:

Date:

Pages: ______, including this cover sheet.

COMMENTS:

From the desk of...

Harbor Development
Maryland Port Administration
2310 Broening Highway
Baltimore, MD 21224

Telephone: 410-631-1102
Fax: 410-631-1057

HarborRock has been working with the Ports identified below with the intent of developing full-scale treatment facilities. The facilities are being designed to recycle and process between 500,000 to 2,500,000 CY/yr of clean and/or contaminated dredge sediments into lightweight aggregate. The size selection will depend on the long-range availability of sediments or other factors.

Cathy Carruthers of the WA State Department of Natural Resources may reference the work performed by HarborRock in Seattle. The facility being designed for this region will process approximately 500,000 CY/Yr. of sediments. Speaking with Laurel Marcus, of Laurel Marcus and Associates of Oakland, may reference the work performed in San Francisco, CA. Ms. Marcus has been retained by the Port of Oakland to evaluate dredge material issues. The facility being considered in San Francisco will process approximately 1,000,000 CY/Yr. Eric Stern of the EPA Region II will reference the work of HarborRock in the New Jersey area. The New Jersey/New York system is being designed to receive approximately 2, 200,000 CY/Yr. of sediments. The US ACOE Philadelphia District will be a reference for the project being considered in their district to process 1,000,000 dry CY/Yr or over 3,000,000 MCY/yr. wet.

Personnel Experience (Section 2.2.2.3.2)

Attachment 7 contains the resumes of key HarborRock personnel.

Below is a summary of the experience and qualifications of several key HarborRock personnel.

Mr. Jeffrey Otto

President of HarborRock Holdings. Mr. Otto has over 20 years experience in developing and building industrial projects. During the past five years he has managed the development and construction of more than $200 million in industrial projects.

Mr. Otto's educational background includes Masters degrees in both Environmental Engineering and Engineering Management and Bachelors degrees in both Mechanical and Agricultural Engineering. He started his career as an engineer for Chicago Bridge & Iron Industries. He oversaw engineering and manufacturing operations and supervised construction of industrial projects ranging from wastewater treatment plants to nuclear power plant upgrades. Subsequently, he was recruited by then Philadelphia Electric to serve as a Lead Auditor in their nuclear **Quality Assurance** department where he evaluated the performance of dozens of firms such as Westinghouse and Bechtel.

His career evolved through Philadelphia Electric to include designing and implementing new programs such as their residential energy efficiency programs (Triple E), several new electric and gas tariff rates, and the incentive based thermal energy storage program. He also served managed the accounts for US Steel, Lukens Steel and

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offices- CMS Companies in Philadelphia, Management Compensation Group (MCG) in Portland, Oregon, and MCG in Chicago, Illinois. His responsibilities have included working with clients in all phases of business start-up, strategic planning, early stage financings, and compensation planning.

Mr. Kimbrough is a frequent speaker at industry seminars on the topics of executive compensation planning and creative early stage financing. Mr. Kimbrough has also authored a number of articles. Mr. Kimbrough currently sits on the boards of VistaCom, Inc., Paradigm Health International and CloseOutNow.com.

Mr. John Lambert

Mr. Lambert has 18 years of technical, project development and financial experience in the energy industry. He previously worked as a Director for Enron North America's environmental energy finance group where he has recently completed a $60 million acquisition of a landfill gas collection and processing company and a $30 million subordinated debt financing for a paper mill expansion. Prior to Enron, Mr. Lambert was a Vice President for Sceptre Power Company, a medium sized power development company, where he led the successful development and financing of a 151 MW power project in Pakistan. Prior to that, he was a Vice President in the Bank of California's project finance group where he closed 10 project financings representing $300 million of direct loan exposure. He began his career as a reservoir petroleum engineer for Exxon Co. U.S.A. Mr. Lambert holds B.S. and M.S. degrees in engineering from the University of Kentucky and an M.B.A. from U.C.L.A. Mr. Lambert is a licensed professional petroleum engineer and is on the Board of Directors of Ecogas Corporation.

Mr. Steve Radel

In addition to his BS in Environmental Science, an MBA and a Law Degree, Mr. Radel has over 15 years of experience in the environmental and aggregates industry. As an environmental manager Mr. Radel has been involved in all aspects of managing environmental programs for sites across the country, including developing site-wide strategies and budgets and assembling teams of experts to implement these strategies. This experience encompasses various state regulatory programs as well as all of the major federal environmental programs to effectively manage these issues on behalf of the corporation. Mr. Radel's environmental experience also includes due diligence of aggregate and building materials operations for acquisition purposes.

Mr. Radel has also been actively involved in establishing a real estate program to ensure the company maximizes value of real assets that have real or perceived environmental issues. This brownfield development effort has provided benefits to the company by integrating the environmental engineering aspects with real estate development opportunities at these sites. These brownfield development opportunities have also allowed Mr. Radel to evaluate and beneficially utilize processed dredged material.

1

Mr. Radel has also been involved in evaluating new business opportunities for the aggregate industry including developing new products and raw materials from recycled material. Mr. Radel has had the opportunity to combine these diverse experiences in the remediation and redevelopment of a former heavy industrial site beneficially using dredge material. This project resulted in total savings to his company in over 30 million dollars and involved the construction of remedial components that also complement the reuse of this site for industrial and commercial purposes after over 15 years of inactivity.

Mr. Richard Ruch, Jr.

Mr. Ruch, who is certified by the Institute of Professional Environmental Practice as a Qualified Environmental Professional, has over 25 years of experience in providing environmental consulting and regulatory assistance to a broad spectrum of industrial facilities and operations throughout the United States and overseas. He has been involved in siting studies and regulatory assessments of new and modified facilities. As a specialist in air quality management, he has provided technical support and regulatory assistance in permitting over 300 facilities, including mineral processing facilities. In this role, he has provided input in the design and operation of the facility. In addition, he has performed environmental/health and safety audits and compliance assessments at a variety of industrial operations.

Mr. Ruch has strong working relationships with his regulatory counterparts in a number of states and EPA regions. He has routinely discussed compliance-related requirements and has negotiated permit conditions. He has served as an expert witness in enforcement actions and civil litigation. Mr. Ruch has also participated at public meeting and hearing to present and discuss the proposed environmental control measures and systems to limit air, water and solid waste pollution.

Subcontractors

Svedala Industries, as HarborRock's strategic partner, will perform the bench scale and pilot scale tests. Svedala is an international supplier of kilns and related equipment. Svedala worldwide sales revenues approach $3 billion annually. Svedala has also agreed to provide standby clean letters of credit or direct project financing on an as needed basis.

An example of the leadership of Svedala in the use of kilns (" Pyroprocessing") is Svedala's development of the pyrokiln thermal encapsulation process that is designed to improve conventional rotary kiln incineration of hazardous waste. The EPA has accepted this technology as a preferred method to treat and stabilize metals found in the waste.

Svedala also acquired Allis Mineral Systems, which was a worldwide supplier of process systems and equipment for the mining, minerals and related industries. This acquisition has further solidified Svedala's leadership position in Pyroprocessing.

The testing firm that will be conducting the pre and post treatment of the sediments is Commercial Testing & Engineering Company, located in Chicago, IL. Svedala has used this firm on numerous applications.

HarborRock will contract for the engineering, procurement and construction of the full-scale plant with the Roberts & Schaefer Company. Roberts & Schaefer was formed in 1903 as an engineering and construction firm serving the coal mining and minerals industries. Today Roberts & Schaefer serve a wide spectrum of industrial clients throughout the U.S. and overseas. Roberts & Schaefer has two operating offices-Chicago and Salt Lake City. Each operating office is fully integrated, providing all phases of engineering design, procurement and construction management services.

As a full service engineering company, Roberts & Schaefer has designed and constructed operating plants for coal, gold, silver, copper, limestone, aggregates, iron ore and clay. Roberts & Schaefer were the engineers for the last lightweight aggregate plant built in the United States.

Roberts & Schaefer and HarborRock have formed a strategic alliance to build all future HarborRock plants.

Facility (Section 2.2.2.3.3.)

HarborRock will develop corporate procedures for environmental safety and for the safety of personnel employed at the full-scale plant to ensure that all applicable worker safety rules, such as OSHA, are in place and that the operations of the facility are appropriate for the situation.

The Bench Scale and Pilot Scale testing will be performed at the Svedala Process Research & Test Center. This facility has conducted over 50 major continuous pilot projects over the past 40 years without any significant work safety issues or environmental upsets

Phase 1 – Bench Scale Testing (Section 2.2.2.4)

Bench Scale Testing (Section 2.2.2.4)

The bench scale tests will be performed for HarborRock at the Process Research and Test Center (PRTC) of Svedala Industries, located in Oak Creek, Wisconsin. **Attachment 8** is a copy of the Phase 1 Bench Scale Testing Program.

The volume of sediment required is approximately one (1) cubic yard of wet, or as received, sediments.

Tests to be performed on the raw materials and post-treatment materials will include full physical and chemical characterization, including conventional pollutants, priority pollutant metals, inorganics and organics, as discussed in the RFP on pages 30 and 31 and the HarborRock Test Program, Table1. In addition, all effluent waste streams or residual solids will be fully characterized and 5 gallons of each liquid waste stream and 5 kg for each residual waste stream will be returned to the MPA.

As discussed in the Test Program, the first steps in the process is to screen the sediment to remove debris, then grind the sediment to a grain size of –100 mesh. After the material is ground, a complete physical and chemical analysis will be performed to understand the oxide composition of the sediments. From the oxide composition, HarborRock is able to determine the suitability of the material for the manufacture of a lightweight aggregate.

At this point in the process, a fraction of the ground sediment will be extruded into pellets and fired in a ported batch kiln to vitrify the pellet into an aggregate. The fired aggregate will be evaluated for bulk density, carbon content and quality. If the aggregate meets ASTM standards for use as a dense aggregate, no further testing will be performed.

The rationale for the decision not to conduct further testing is based on experience, economics and the methodology requested in this RFP. From the oxide composition, which is determined from the chemical testing, and from the characteristics of the fired aggregate, HarborRock is experienced to accurately predict the quality of the lightweight aggregate that would be produced if the material were preconditioned by calcination. This further testing is also not economically justifiable at this point in the process because the exact same tests would be repeated in Phase 2.

It is important for the Sate and the MPA to understand the nature of the HarborRock process and the degree of testing needed to demonstrate that the technology is able to decontaminate sediments and produce a useful product. The methodology outlined in this RFP calls for repeated demonstration of the technology using larger quantities of materials at each stage. For the HarborRock process only a limited amount of sediment is necessary to determine if the sediments can produce a quality aggregate, with or without the benefit of the calcination step, and the decontamination effectiveness of the process. Once that is determined, no further testing is needed to validate the concept on a commercial scale. The knowledge on how to prepare the raw materials, make extrusions, operate a kiln and control the associated emissions has been proven for centuries for kilns of all sizes. The State and the MPA do not have to reprove the known.

If the State and the MPA were to grant HarborRock an exemption from the requirement to perform the testing associated with Phase 2, it would perform the complete battery of testing on the sediments during Phase 1. This would include the calcination step to ensure the sediments produce a superior quality lightweight aggregate and would perform the ASTM testing required for lightweight aggregate. By not having to perform the Phase 2 testing, HarborRock's costs would be reduced by almost two-fold. It would eliminate costs for: collection and shipment of samples, physical and chemical testing and sediment characterization; facility costs; repetitive testing and analysis on the final product.

Schedule

The bench scale work and generation of the test report, which will outline the potential for Pilot Scale Operations, will be completed within the three (3) months allotted time frame.

Site Requirements and Location (Section 2.2.2.4.1)

The facility that will be used to conduct the bench scale test is the Svedala Industries, Inc., Process Research & Test Center (PRTC) located in Oak Creek, WI. The PRTC is a fully equipped facility that can perform complex tests on dredged materials simulating complete commercial process flow sheets. The PRTC encompasses an area of 60,000 square feet, which allows a variety of tests to be performed under one roof. This will provide for process continuity, allowing for important unit processes to be investigated in an uninterrupted, integrated manner.

Quality Assurance (section 2.2.2.4.2)

The Svedala lab will schedule and conduct the bench scale kiln test run in accordance with the requirements of this RFP. The sediments will be stored at 4 degrees C and the test will start within 48 hours of receipt. Commercial Testing and Engineering Company, Chicago, Illinois, will conduct pre and post-treatment testing, observing appropriate U.S. EPA guidelines.

Phase 2 – Pilot Scale Testing (section 2.2.2.5)

(Nominally 100 Cubic Yards Processed)

Site Requirements and Location (Sections 2.2.2.5.1 &2.3.5.1.1.)

HarborRock will conduct the Pilot Scale testing at the Svedala's Process Research & Test Center, which is located in Oak Creek, Wisconsin. This facility is fully staffed and is equipped with an existing pilot scale kiln and all auxiliary equipment needed to conduct pilot scale tests. Therefore, HarborRock does not need to lease space from the MPA. The only work that will be performed on-site is the collection and loading the sediments for transport.

Permitting and Regulatory Requirements (Section 2.3.5.1.2)
(Pg 32 2.3.5.1.2)

HarborRock intends to conduct the Pilot Scale testing at the Svedala Process Research & Test Center. As previously mentioned, this facility is fully permitted to perform pilot scale test work, therefore there are no further regulatory requirements known at present.

Post Treatment Management Requirements (Section 2.3.5.1.3)
(Pg 32 2.3.5.1.1.)

While Commercial Testing and Engineering Company is verifying the post-treatment characterization of the lightweight aggregate produced, the material will be stored in plastic lined drums which will be sealed. Upon verification that the material passes all TCLP tests it will shipped to HarborRock for use as samples.

Debris and excess water extracted from the raw sediments after characterization will be landfilled as appropriate.

Quality Assurance

The purpose of this test is to verify the decontamination efficiency of the system and that a range of aggregates, including high quality lightweight aggregate, can be produced commercially. The degree of testing being performed during this Phase 2 of this RFP is the full extent of the testing necessary for Svedala to design and make process guarantees for a full-scale plant. Therefore, it is imperative that all process variables are fully evaluated, implemented, controlled and documented.

Examples of the process variables that are recorded in addition to the complete physical and chemical characterization of the materials include:

1. Performing various screening cuts on the raw sediments and documenting the amount of materials retained per screening.
2. Optimizing the pre-conditioning temperature, retention time and degree of carbon element burnout.
3. Fuel consumption in all process equipment.
4. Optimal moisture of the pellet extrusions.
5. Verification of requirement to dry the extruded pellets prior to firing in the kiln.
6. Temperature and retention time in the kiln.
7. Pellet expansion ratios plotted against temperature.
8. Pellet strength and density.
9. Emissions profiles

Pilot Scale Test Procedures (Section 2.3.5.2)

Attachments 3 & 8, the HarborRock Pilot Kiln Test Programs outline the procedures used and the tests that will be performed during all stages of the process.

Quality Assurance Procedures (Section 2.3.5.2.1.)

HarborRock intends to outline the testing and procedural requirements of this RFP to ensure that these requirements are carried out by the contract facility. In addition, the staff of the Svedala Process Research & Test Center will be made aware that the material is contaminated and not to come in contact with the material. Svedala operates their test facility in order to conduct tests for clients throughout the United States on a variety of material including hazardous waste and have a history of OSHA compliance and safe work practices.

The entire treatment process will be simulated by the pilot kiln test. Therefore, to accurately model the conditions to be found in the commercial scale, the entire process is a sealed system with no uncontrolled discharges of any sort. The system contains an afterburner to ensure the air emissions are treated to meet code.

Physical and Chemical Characterization (pg 33 S 32.3.5.2.11)

As outlined in this section, complete testing of the material will occur by an independent firm.

Schedule- including report (Section 2.3.5.2.12)

The Phase 2 testing and report plus market study will be completed within the three (3) months allotted as shown below.

Item Description	*Weeks Conducted*	
Market study	Weeks	1 through 8
Collect & ship raw materials	Weeks	1
Analyze raw materials	Weeks	2 & 3
Screen materials	Week	2
Dredge Drying	Week	3
Flash conditioning	Week	4
Laboratory study	Weeks	5
Pellet feed preparation	Weeks	6
Rotary kiln test	Weeks	6
Aggregate analysis	Weeks	7 & 8
Emissions analysis	Weeks	7
Final report	Weeks	8 - 10

Phase 3 – Demonstration Scale Testing

(Nominally 30,000 Cubic Yards)

This RFP asked for an analysis of the prospects for scaling up the system to a commercial scale. With the HarborRock process, upon completion of Phase 1 and most certainly Phase 2, the performance of any additional testing (demonstration scale testing or production scale) is not necessary to make a determination of the prospects for scaling-up the system to any size production scale plant desired by the MPA. The level of testing done through Phases 1& 2, unless an exemption is given for the Phase 2 testing, is more than enough testing needed by Svedala and HarborRock to guarantee the process on a commercial scale. Please see **Attachment 10**, which is a letter from Svedala documenting this fact.

Current State of Development (Section 2.3.6.1)

The use of kilns is commonplace. They have been used to make road asphalt, cement and manufactured aggregates for decades. The ability of a kiln to fire an aggregate does not need to be further demonstrated. The level and type of air pollution control equipment required when processing materials of all types clean or contaminated, is readily calculated depending on the concentrations of the contaminants and the material throughput of the system. Svedala, and other kiln suppliers, have kiln systems of all sizes operating around the world. The prospects of scaling up to any size plant is also straightforward.

For the purposes of meeting the intent of this RFP, and for HarborRock's business plan, the question that needs to be answered is not whether a system can be designed to meet the full scale commercial needs of the MPA, but if the sediments from Maryland's harbors produce a marketable aggregate. If high quality aggregate can be produced, the technology, engineering and construction expertise to build a plant is already demonstrated and in place.

The answer to the question of whether or not a quality aggregate can be produced from Maryland sediments will be obtained in Phase 1. In addition the treatment effectiveness of the system will also be determined in Phase 1. It does not need to be further demonstrated by running additional material through a pilot test kiln. t. In fact, the Svedala facility is not equipped to handle 30,000 CY of material. That amount of material would preclude them from using their facility for any other testing.

Kilns are rated or measured by the tons of finished product they produce. Sizes of kilns for the manufacture of lightweight aggregate generally range from 250 tons per day, up to 1,500 tons per day. As a rule of thumb, one cubic yard of sediments @ 30% solids will produce about 700 pounds of finished aggregate, or roughly a ratio of 3 CY of 30% solid sediment to 1 ton of finished LWA.

Using the 3 to 1 ratio, in order to produce 250 tons per day of aggregate, 750 CY of wet sediment is required. On an annual basis, assuming 330 days per year of operation, roughly 250,000 CY of sediments are needed. This example is used because a 250-ton per day plant is generally considered the smallest scale commercial kiln practical to construct and operate. Therefore, it is impractical to build a facility to process 30,000 CY/yr. or even 100,000 CY/yr.

It is also not practical to attempt to use an existing rotary kiln previously used in another application for the manufacture of Lightweight aggregate. The overall design of the system, including airflow rates, the kiln bed design, and feed mechanisms for the kiln are all different, thus making this option also impractical.

For HarborRock to participate in Phases 3 and 4, it will require the construction of a commercial scale facility. The financial implications of this are discussed in the price proposal. It is our opinion, however, that this approach is in the best interests of the State and MPA for the beneficial reuse of clean or contaminated sediments.

The positive benefits that would result to the State and the MPA by authorizing HarborRock to construct a commercial scale facility after Phase2 and avoid Phases 3 and 4 are at least the following:

1. At least fifteen (15) months saved from the Phase 3, Demonstration scale testing.
2. At least thirty six (36) months saved for Phase 4 development.
3. The expense of funding Phases 3 & 4.
4. The opportunity costs of delay in terms of finances plus the loss of existing disposal capacity for material that otherwise would have been processed by HarborRock.

In contrast to investing the additional four (4) years for development plus the associated expense, at the end of Phase 1 or 2, HarborRock will be in a position to offer the MPA, the following:

1. The mass and energy balance, including emissions, for any size production or full-scale facility that best fits the needs of the MPA.
2. A budget for the costs to engineer, procure and construct (EPC) a full-scale facility, backed by the firms of Svedala Industries, Inc., and the Roberts & Schaefer Company.
3. HarborRock will be able to offer a price proposal/pricing structure for any size plant agreed to by the MPA.

Site Requirements and Location

The site requirements for a full-scale or expanded scale plant are approximately 20 acres, excluding the containment area.

The utilities required include high voltage electric service, natural gas, small capacity potable water service and rail service.

The plant will directly employ between thirty to fifty people, depending on plant size, in family wage jobs. There will also be about five personnel in sales, marketing and administration positions. Indirect jobs, truck drivers etc. is estimated at about one hundred. Construction jobs will be for a period of approximately eighteen months and will employ several hundred workers.

Schedule

The construction schedule is about twelve (12) to fifteen (15) months for a full-scale facility.

Permitting and Regulatory Requirements (pg 32 2.3.6.1.2)

Not applicable. Please see discussion above in Current State of Development.

Post Treatment Management Requirements (pg 34 2.3.6.1.4)

Not applicable. Please see discussion above in Current State of Development.

Quality Assurance Procedures (2.3.6.1.4 pg 34)

Not applicable. Please see discussion above in Current State of Development

Physical and Chemical Characterization (pg 35 S 2.3.6.2.11)

Not applicable. Please see discussion above in Current State of Development

Scale-Up Potential:
Production, Full-Scale and Expanded Full-Scale Operations

Phase 4: Production Scale: (100,000 CY/Yr.)
Phase 5: Full-Scale Operations: (500,000 CY/Yr.)
Phase 6: Expanded Full-Scale Operations: (500,000 – 2,000,000 CY/Yr.)

Please see the discussion above in Phase 3: Demonstration scale.

As discussed in the section "Organizational Experience", HarborRock has currently projects under development that range in processing capacity from 500,000 CY/yr to over 3,000,000 CY/yr. This is the scale of plants common for the manufacture of aggregates.

As discussed in the State of Maryland's Strategic Plan for Dredged Material Management, immediate action, with regard to dredge material disposal, is needed to protect the state's investment of $1 billion in port infrastructure and the port's contribution to the Sate. This means for the near term existing disposal sites need to be expanded. To meet the long term needs, an Upper Bay Island Placement Site is contemplated. The lifetime cost/cubic yard is estimated at $3.60-$8.60 (present worth) for this project.

The capacity of the Long Term Site is 100 million cubic yards, which provides a useful life of 25 years. It will require years to permit and construct and is shown to be required in FY09. HarborRock is an attractive alternative to this option.

A HarborRock plant can be designed after Phase 1 or 2 to meet the full-scale requirements desired by the MPA. It can be constructed in about twelve (12) to fifteen (15) months and it has a useful life of over 50 years. Commencing construction of the HarborRock after Phase 2 will save the MPA at least four years time and preserves valuable disposal capacity at existing sites. Preserving this capacity by bringing on line an adequately sized HarborRock plant early in the process may also eliminate the need for the construction of another disposal island.

As discussed in the Product Uses section, the supply of aggregate in the Baltimore-Washington corridor is becoming a major issue. Competing land uses are moving sources of aggregate further away from the point of use. The cost to bring the aggregate back into the urban areas continues to escalate, creating an even greater burden on society in the form of higher costs, infrastructure burden and truck emissions. The market study that will be conducted in Phase 2 will verify these statements. They are mentioned here to illustrate the value to the MPA and the State of having a renewable source of dredged material disposal and aggregate supply on line sooner than later.

Current State of Development (pg 36 2.3.7.1)

Please see the discussion above in Phase 3: Demonstration scale.

Site Requirements and Location

Please see the discussion above in Phase 3: Demonstration scale.

Schedule and Approach to Scale-Up

Please see the discussion above in Phase 3: Demonstration scale.

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EVALUATION OF SEATTLE, WASHINGTON HARBOR DREDGINGS AS A SOURCE OF RAW MATERIAL TO PRODUCE LIGHTWEIGHT AGGREGATE

PROJECT NO. 9-22885-863-00-31

AUGUST 20, 1999

Written By:

S. M. Cohen
General Manager
Research & Development

EXECUTIVE SUMMARY

The results in this report indicate that a lightweight aggregate (LWA) can be produced from the Seattle harbor dredgings. Systems will require removal of the plus 50 mesh fraction which contains wood fibers and sea shells.

It was determined that due to the high levels of organic carbon present in the -50 mesh fraction (76% of dredging sample), it would require that the sample be diluted with a ground shale or clay preferably a known expandable material. In this study using in a 50/50 mix with a slightly weathered shale obtained from Timber, OR a 28 to 42 lb/cuft with a 10 to 60% volume expansion and a high compressive strength product was produced within a temperature range of 1950° to 2000° F. The amount of shale required most likely can be reduced by using an unweathered shale sample from this location.

Emission tests from the -50M dredge does indicate levels of THC, CO, CH_4 and SO_2 present which may need special control devices in any commercial installation.

The next phase of this program if results are of interest is to obtain larger samples of both dredge and shale for a full pilot rotary kiln test program to produce enough product for a complete ASTM method evaluation.

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TEST RESULTS (Chemistries & Burn Tests)

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On 7/29/99 we received four cooler chests containing 68 jar samples of Seattle Harbor dredgings as shown in the list of jar markings given in the appendix. After consulting with Mr. Jeff Otto of E Solutions we were directed to combine all samples into a composite sample and test materials as a single sample.

Visual inspection of the composite showed the presence of both wood fibers and sea shell in the coarser fractions. A full screen analysis of the composite sample was made (Table 1). Based on the sizing we made separate fraction of +¼", -¼" + 16 mesh, -16 mesh + 40 mesh, -40 mesh + 50 mesh, -50 mesh +100 mesh and - 100 mesh materials. Photo taken of each of these fraction are given in appendix. The -100 mesh fraction (which represents 67.8% of the total sample) fraction was further evaluated and was found to have an average size of 12μ. **(Figure 1 and Table 2).**

Chemical analyses were determined of the composite sample and the screen fraction indicated above **(Table 3 to Table 9)**. These analyses were then plotted on our composite diagram (Figure 2) which indicates if a material would fire to a mass viscous enough to trap a internal gas if produced at the necessary temperature. As shown the 50 mesh x 0 fraction plotted is well within the required area.

In order to fully evaluate the bloating potential a series of programmable electric muffle burn test were made on extruded ½"⌀ x ¾" pellets **(Figure 3)**. Initial tests were made on 100%, 50m x 0 dredge material. The results of these burn tests are given in **Tables 10 to 12**. As shown, only a slight expansion was noted until melting and fusion occurred which was with the lightest sample shown at 39.2 lbs/cuft with a 30% expansion. **(Figure 3)**. This product could not be made commercially due to the fusion problem seen at 2000° F.

One attempt was made, was adding 0.5% Bunker "C" oil **(Table 13)** which shows no improvement over the results found without oil added at the at the same temperature.

Although the material plotted well within composition diagram the presence of high levels of organic carbon (3%) we believe is the cause of the poor bloating performance in the muffle furnace tests. Previous R&D programs conducted by us had determined that high organic carbon or high extrusion moistures can cause problems.

In the case of high carbon content in many cases we believe it is caused by early heat up of particles internally burning out or reducing the potential bloating gas agent prematurely, leaving little or none left when the mass becomes viscous enough to trap it and bloat.

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We have found only two ways to overcome this problem, the first is deliberately burning out the carbon present and then extruding both with controlled amounts of bloating gas agent using the extrusion process. This may require a higher capitol investment in equipment. It may also increase the overall fuel cost if the carbon content is not high enough to support its own burn out in a flash calciner system.

The second approach is the one successfully used with the NY/NJ Harbor dredgings. In this case we dilute the dredging carbon level by mixing the dredge material with a pulverized know bloating shale. What this does is dilute the carbon level to a point where it cannot cause a internal particle heat up temperature to burn out all of the potential bloating agent in the dredge and that in the bloatable shale. Both a 50/50 mix and a 70% dredged 30% shale mix made a high quality product in this case.

In order to check out the second approach with the limited quantity of Seattle dredge on hand we utilized the successful shale component from NY with 50% dry dredge which produced a high quality product as shown in **Tables 13 to 17**. The actual product made at 25.1 lbs/cuft is shown in **Figure 4**.

We repeated this approach using a known bloatable shale obtained from the Portland, Oregon area. The results of the electric muffle burn series are shown in **Tables 18 to 20** . The 28 lbs/cuft product is shown in **Figure 5**. Again it appears that a high quality aggregate was produced using a 50/50 mix. There is some concern that the shale samples used was slightly weathered and that even better results may be possible with better samples of the shale.

Based on the results shown in the above two series of burns a reduced level of shale addition should be possible. This would have to be confirmed when larger samples of dredge and shale are made available.

All the results obtained in all the burn series made are summarized in **Table 21** and illustrated in **Figure 6 and 7**. The compressive strength figures given in each case can be compared to those obtained on commercial products as shown in **Table 22**, which also gives their actual end uses.

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Table 1

FULLER COMPANY - RESEARCH DEPARTMENT

LABORATORY SCREEN ANALYSIS

Sample From: Enron	Date Rec'd: 7/27/99
TX	Sample No. 990856C
Material: Composite Dredging from Seattle	Was Screen Sample Dried?
	Yes No X
Project No.: 9-22885-863-02-31	Wt.Sample Tested: 500.1 gms.
Moisture as Rec'd.: 53.0% @ 105° C	Bulk Dens. #/cu.ft(wet)
Method of Screening: Wet screen on 100m, Rotap dry +100 mesh	Bulk Dens. #/cu.ft(dry)

U.S. Screen	Grams Retained	% Retained		Cumul.% Retained	Cumul.% Passing	
+2 inch			2 inch			
-2 +1 ¾ inch			1 ¾ inch			
-1 ¾ +1 ½ inch			1 ½ inch			
-1 ½ +1 ¼ inch			1 ¼ inch			
-1 ¼ +1 inch			1 inch			
-1 +¾ inch			¾ inch		100.0	
-¾ +½ inch	5.5	2.3	½ inch	2.3	97.7	
-½ +⅜ inch	0.4	0.2	⅜ inch	2.5	97.5	5.2%
-⅜ +¼ inch	6.3	2.7	¼ inch	5.2	94.8	
-¼ +4 mesh	1.5	0.6	4 mesh	5.8	94.2	
-4 +6 mesh	3.8	1.6	6 mesh	7.4	92.6	
-6 +8 mesh	4.8	2.0	8 mesh	9.4	90.6	7.8%
-8 +12 mesh	4.1	1.7	12 mesh	11.1	88.9	
-12 +16 mesh	4.5	1.9	16 mesh	13.0	87.0	
-16 +20 mesh	4.9	2.1	20 mesh	15.1	84.9	
-20 +30 mesh	6.1	2.6	30 mesh	17.7	82.3	7.6%
-30 +40 mesh	6.8	2.9	40 mesh	20.6	79.4	
-40 +50 mesh	8.0	3.4	50 mesh	24.0	76.0	3.4%
-50 +70 mesh	9.6	4.1	70 mesh	28.1	71.9	8.2%
-70 +100 mesh	9.7	4.1	100 mesh	32.2	67.8	
-100 +140 mesh	159.2	67.8	140 mesh			
-140 +170 mesh			170 mesh			
-170 +200 mesh			200 mesh			
-200 +325 mesh			325 mesh			
-325 mesh						
Total	235.2	100.0				

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SIGNED: Leslie S. Dutt

DATE: 7/27/99

Figure 1

FULLER COMPANY
Sample Name: Enron - Seattle
ID Number: 990858C
File Name: Composite
Material: Seattle Harbor Dredgings Run Date: 7/27/99

Scalped @ 100m
67.8% - 100m

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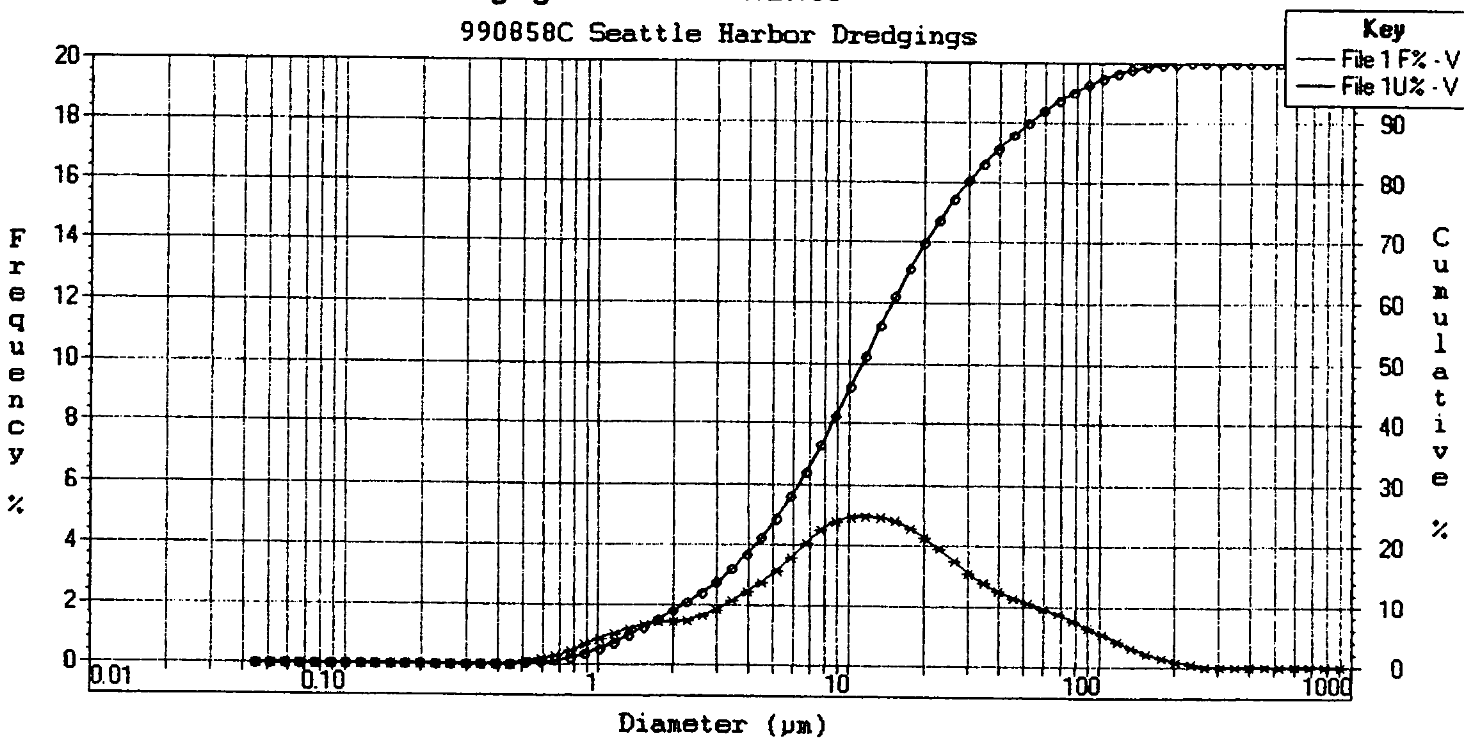

Sample : File 1	Diameter on %	Percentage on Diameter
Dist. Base : Volume	10.0% : 2.194 (µm)	150.000 (µm) : 99.4%
Mean (µm) : 20.72	20.0% : 4.223 (µm)	90.000 (µm) : 96.5%
Median (µm): 11.21	50.0% : 11.209 (µm)	75.000 (µm) : 94.8%
Std.Dev(µm): 26.78	75.0% : 24.029 (µm)	45.000 (µm) : 87.9%
Spec. Area : 10873	90.0% : 51.590 (µm)	20.000 (µm) : 69.9%

Table 2

FULLER COMPANY

Sample Name: Enron - Seattle
ID Number: 990858C
File Name: Composite
Material: Seattle Harbor Dredgings Run Date: 7/27/99
Shape: 1 Ref. Index: 1.44-0.39 Laser: 80.673 Red: 83.538 Blue: 80.168
Material : Dust Composite
Source : Kiln #2
Project Num : 002-17
Operator : SDB

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No.	SIZE(μm)	FREQ.%	U.SIZE%	No.	SIZE(μm)	FREQ.%	U.SIZE%
(1)	1.000	2.54	2.54	(13)	53.000	2.49	90.36
(2)	2.000	6.46	9.00	(14)	75.000	4.43	94.79
(3)	3.000	4.90	13.90	(15)	90.000	1.76	96.55
(4)	4.000	4.96	18.87	(16)	106.000	1.21	97.76
(5)	5.000	4.85	23.72	(17)	150.000	1.61	99.37
(6)	6.000	4.80	28.52	(18)	212.000	0.57	99.94
(7)	10.000	17.30	45.82	(19)	300.000	0.06	100.00
(8)	15.000	14.63	60.44	(20)	425.000	0.00	100.00
(9)	20.000	9.42	69.87	(21)	600.000	0.00	100.00
(10)	25.000	6.10	75.97	(22)	850.000	0.00	100.00
(11)	32.000	5.62	81.59	(23)	1000.000	0.00	100.00
(12)	45.000	6.28	87.87				

Statistical Information		Diameter on %		Percentage on Diameter	
Dist. Base :	VOLUME	10.0% :	2.172 (μm)	150.000 (μm) :	99.4%
Mean (μm) :	20.715	20.0% :	4.214 (μm)	90.000 (μm) :	96.5%
Median (μm) :	11.209	50.0% :	11.229 (μm)	75.000 (μm) :	94.8%
Std.Dev(μm) :	26.783	75.0% :	24.128 (μm)	45.000 (μm) :	87.9%
Spec. Area :	10873	90.0% :	51.755 (μm)	20.000 (μm) :	69.9%

Table 2 cont.

CONFIDENTIAL

Fuller Company — Analysis Report

LA-900 Laser Scattering Particle Size Distribution Analyzer — Jul/27/'99
Distribution Graph [990858C] — Version 2.00d
Sample Name: Enron - Seattle — ID#:990727-388-15:03:57

#	Size µm	Frequency %	UNDER SIZE %	#	Size µm	Frequency %	UNDER SIZE %
[1]	1019.5	0.0	100.0	[38]	6.719	4.1	32.0
[2]	890.1	0.0	100.0	[39]	5.866	3.6	27.9
[3]	777.1	0.0	100.0	[40]	5.122	3.1	24.3
[4]	678.5	0.0	100.0	[41]	4.472	2.8	21.2
[5]	592.3	0.0	100.0	[42]	3.904	2.5	18.4
[6]	517.2	0.0	100.0	[43]	3.408	2.1	15.9
[7]	451.5	0.0	100.0	[44]	2.976	1.8	13.8
[8]	394.2	0.0	100.0	[45]	2.598	1.6	12.0
[9]	344.2	0.0	100.0	[46]	2.268	1.5	10.4
[10]	300.5	0.0	100.0	[47]	1.980	1.4	8.9
[11]	262.3	0.0	100.0	[48]	1.729	1.4	7.5
[12]	229.0	0.1	100.0	[49]	1.509	1.3	6.1
[13]	200.0	0.2	99.9	[50]	1.318	1.2	4.8
[14]	174.6	0.3	99.7	[51]	1.150	1.0	3.6
[15]	152.4	0.4	99.4	[52]	1.004	0.8	2.6
[16]	133.1	0.6	99.0	[53]	0.877	0.7	1.7
[17]	116.2	0.9	98.3	[54]	0.765	0.5	1.1
[18]	101.4	1.1	97.5	[55]	0.668	0.3	0.6
[19]	88.58	1.3	96.4	[56]	0.583	0.2	0.3
[20]	77.33	1.5	95.2	[57]	0.509	0.1	0.1
[21]	67.52	1.7	93.6	[58]	0.445	0.0	0.0
[22]	58.95	1.9	91.9	[59]	0.388	0.0	0.0
[23]	51.47	2.1	90.0	[60]	0.339	0.0	0.0
[24]	44.93	2.3	87.9	[61]	0.296	0.0	0.0
[25]	39.23	2.5	85.6	[62]	0.258	0.0	0.0
[26]	34.25	2.8	83.0	[63]	0.225	0.0	0.0
[27]	29.90	3.1	80.3	[64]	0.197	0.0	0.0
[28]	26.11	3.5	77.1	[65]	0.172	0.0	0.0
[29]	22.79	3.9	73.6	[66]	0.150	0.0	0.0
[30]	19.90	4.3	69.7	[67]	0.131	0.0	0.0
[31]	17.37	4.6	65.5	[68]	0.114	0.0	0.0
[32]	15.17	4.8	60.9	[69]	0.100	0.0	0.0
[33]	13.24	4.9	56.1	[70]	0.087	0.0	0.0
[34]	11.56	5.0	51.1	[71]	0.076	0.0	0.0
[35]	10.09	4.9	46.2	[72]	0.066	0.0	0.0
[36]	8.815	4.8	41.3	[73]	0.058	0.0	0.0
[37]	7.696	4.5	36.5	[74]	0.050	0.0	0.0

Horiba Instruments, Incorporated

Table 3

Chemical Analysis (Wt.%, Dry Basis)

03-Aug-99

Date: 7/28/99
Page: 1074
Analytical No: C991074
Lab No: 990858C
Project No: 9-22885-863-02-31 CONFIDENTIAL
Cust. Name: ENRON
Locartion Texas
Samp. Descr.: Seattle Dredge Composite; As Rec'd

H2O:	--	Free CaO:		Fe(+2):
HM:		Avail CaO:		Fe(+3):
HOR:		TAO:		Fe(0):
SiO2:	49.47	Avail MgO:		Fe(tot):
Al2O3:	12.68	Free SiO2:		Ni(0):
Fe2O3:	5.58	BTU/Lb:		Ni(+2):
CaO:	5.50	Vol:		Ni (tot):
MgO:	3.43	Ash:		Ag:
K2O(X-ray):		FC:		As:
K2O(AA):	1.38	CaCO3(tot):		Au:
Na2O(X-ray):		MgCO3:		Ba:
Na2O(AA):	3.76	CaCO3(net):		Be:
P2O5:	0.27	Sulfide S:	0.52	Cd:
TiO2:	0.64	Ult C:		Co:
Mn2O3:	0.12	Ult H:		Cr:
SO3(Leco):	1.60	Ult N:		Cu:
SO3(Wet):		Ult S:		Hg:
Loss @ 900 C:	15.48	Ult O:		Mg:
Loss @ 500 C:		pH:		Mo:
Total:	99.91			Ni:
C:	2.64			Pb:
CO2:				Sb:
Cl:	1.66			Se:
F:	0.00			Tl:
				Zn:

Table 4

Chemical Analysis (Wt.%, Dry Basis)

03-Aug-99

Customer Name: ENRON
Location Texas
Project No: 9-22885-863-02-31
Sample Description: Seattle Dredge Composite; +1/4"
Lab No: 990858C
Analytical No: C991068

CONFIDENTIAL

Loss @ 105 C:	--
SiO2:	46.65
Al2O3:	9.33
Fe2O3:	3.91
CaO:	5.12
MgO:	1.83
K2O:	0.76
Na2O:	1.94
SO3(Total):	1.20
P2O5:	0.07
TiO2:	0.35
Mn2O3:	0.10
Loss @ 900 C:	28.65
Total:	99.91
Cl:	0.466
C:	7.74
CO2:	
CaCO3(net):	
MgCO3:	
CaCO3(total):	
Free SiO2:	
Loss @ 500 C:	
Sulfide S:	0.42
Free CaO:	

Table 5

Chemical Analysis (Wt.%, Dry Basis)

03-Aug-99

Customer Name:	ENRON
Location	Texas
Project No:	9-22885-863-02-31
Sample Description:	Seattle Dredge Composite; -1/4"+16 M
Lab No:	990858C
Analytical No:	C991069

CONFIDENTIAL

Loss @ 105 C:	--
SiO2:	35.16
Al2O3:	7.35
Fe2O3:	3.49
CaO:	20.36
MgO:	1.61
K2O:	0.85
Na2O:	2.24
SO3(Total):	1.40
P2O5:	0.40
TiO2:	0.31
Mn2O3:	0.08
Loss @ 900 C:	26.53
Total:	99.77
Cl:	0.058
C:	3.60
CO2:	
CaCO3(net):	
MgCO3:	
CaCO3(total):	
Free SiO2:	
Loss @ 500 C:	
Sulfide S:	0.45
Free CaO:	

Table 6

Chemical Analysis (Wt.%, Dry Basis)

03-Aug-99

Customer Name: ENRON
Location Texas
Project No: 9-22885-863-02-31
Sample Description: Seattle Dredge Composite; -16+40 M
Lab No: 990858C
Analytical No: C991070

CONFIDENTIAL

Loss @ 105 C:	--
SiO2:	47.20
Al2O3:	8.72
Fe2O3:	3.39
CaO:	8.92
MgO:	2.03
K2O:	0.86
Na2O:	2.26
SO3(Total):	2.10
P2O5:	0.42
TiO2:	0.35
Mn2O3:	0.09
Loss @ 900 C:	23.51
Total:	99.85
Cl:	0.072
C:	7.36
CO2:	
CaCO3(net):	
MgCO3:	
CaCO3(total):	
Free SiO2:	
Loss @ 500 C:	
Sulfide S:	0.75
Free CaO:	

Table 7

Chemical Analysis (Wt.%, Dry Basis)

03-Aug-99

Customer Name: ENRON
Location Texas
Project No: 9-22885-863-02-31
Sample Description: Seattle Dredge Composite; -40+50 M
Lab No: 990858C
Analytical No: C991071

CONFIDENTIAL

Loss @ 105 C:	--
SiO2:	56.38
Al2O3:	9.28
Fe2O3:	3.14
CaO:	5.08
MgO:	2.33
K2O:	1.04
Na2O:	2.41
SO3(Total):	1.78
P2O5:	0.28
TiO2:	0.30
Mn2O3:	0.09
Loss @ 900 C:	17.78
Total:	99.89
Cl:	0.072
C:	4.85
CO2:	
CaCO3(net):	
MgCO3:	
CaCO3(total):	
Free SiO2:	
Loss @ 500 C:	
Sulfide S:	0.64
Free CaO:	

Table 8

Chemical Analysis (Wt.%, Dry Basis)

03-Aug-99

Customer Name: ENRON
Location Texas
Project No: 9-22885-863-02-31
Sample Description: Seattle Dredge Composite; -50+100 M
Lab No: 990858C
Analytical No: C991072

CONFIDENTIAL

Loss @ 105 C:	--
SiO2:	64.65
Al2O3:	11.32
Fe2O3:	2.93
CaO:	4.49
MgO:	2.30
K2O:	1.00
Na2O:	2.49
SO3(Total):	1.10
P2O5:	0.19
TiO2:	0.37
Mn2O3:	0.10
Loss @ 900 C:	8.88
Total:	99.82
Cl:	0.045
C:	2.72
CO2:	
CaCO3(net):	
MgCO3:	
CaCO3(total):	
Free SiO2:	
Loss @ 500 C:	
Sulfide S:	0.40
Free CaO:	

Table 9

Chemical Analysis (Wt.%, Dry Basis)

03-Aug-99

Customer Name:	ENRON
Location	Texas
Project No:	9-22885-863-02-31
Sample Description:	Seattle Dredge Composite; 100 M
Lab No:	990858C
Analytical No:	C991073

CONFIDENTIAL

Loss @ 105 C:	--
SiO2:	52.01
Al2O3:	15.09
Fe2O3:	6.65
CaO:	3.09
MgO:	4.21
K2O:	1.59
Na2O:	2.93
SO3(Total):	1.90
P2O5:	0.27
TiO2:	0.80
Mn2O3:	0.13
Loss @ 900 C:	11.21
Total:	99.88
Cl:	0.645
C:	1.95
CO2:	
CaCO3(net):	
MgCO3:	
CaCO3(total):	
Free SiO2:	
Loss @ 500 C:	
Sulfide S:	0.65
Free CaO:	

Figure 2

FULLER®
RESEARCH & DEVELOPMENT

® A member of the F.L.Smidth-Fuller Engineering Group

Composition diagram of major oxides showing area in which substances fire to a mass viscous enough to insure good bloating.

CUSTOMER: Enron - Seattle Project

DATE: 8/3/99

TEST NO	MATERIAL
1.	+ 1/4"
2.	-1/4" +16M
3.	-16M + 40M
4.	-40M +50M
5.	-50M + 100M
6.	-100M
7.	Composite
8.	-50M x 0

15

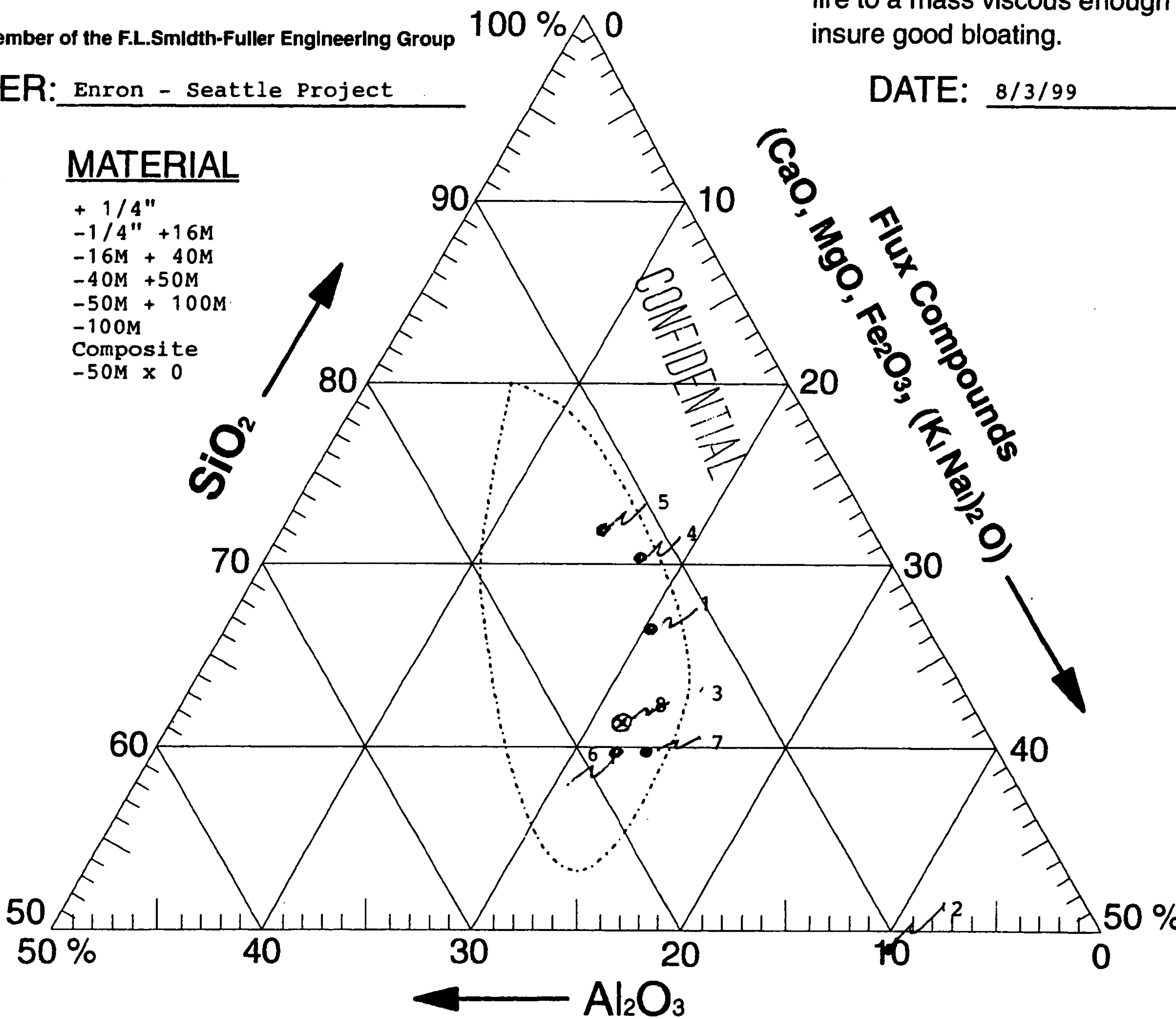


FIGURE 3
SEATTLE DREDGE EXTRUDED FEED PELLETS

CONFIDENTIAL

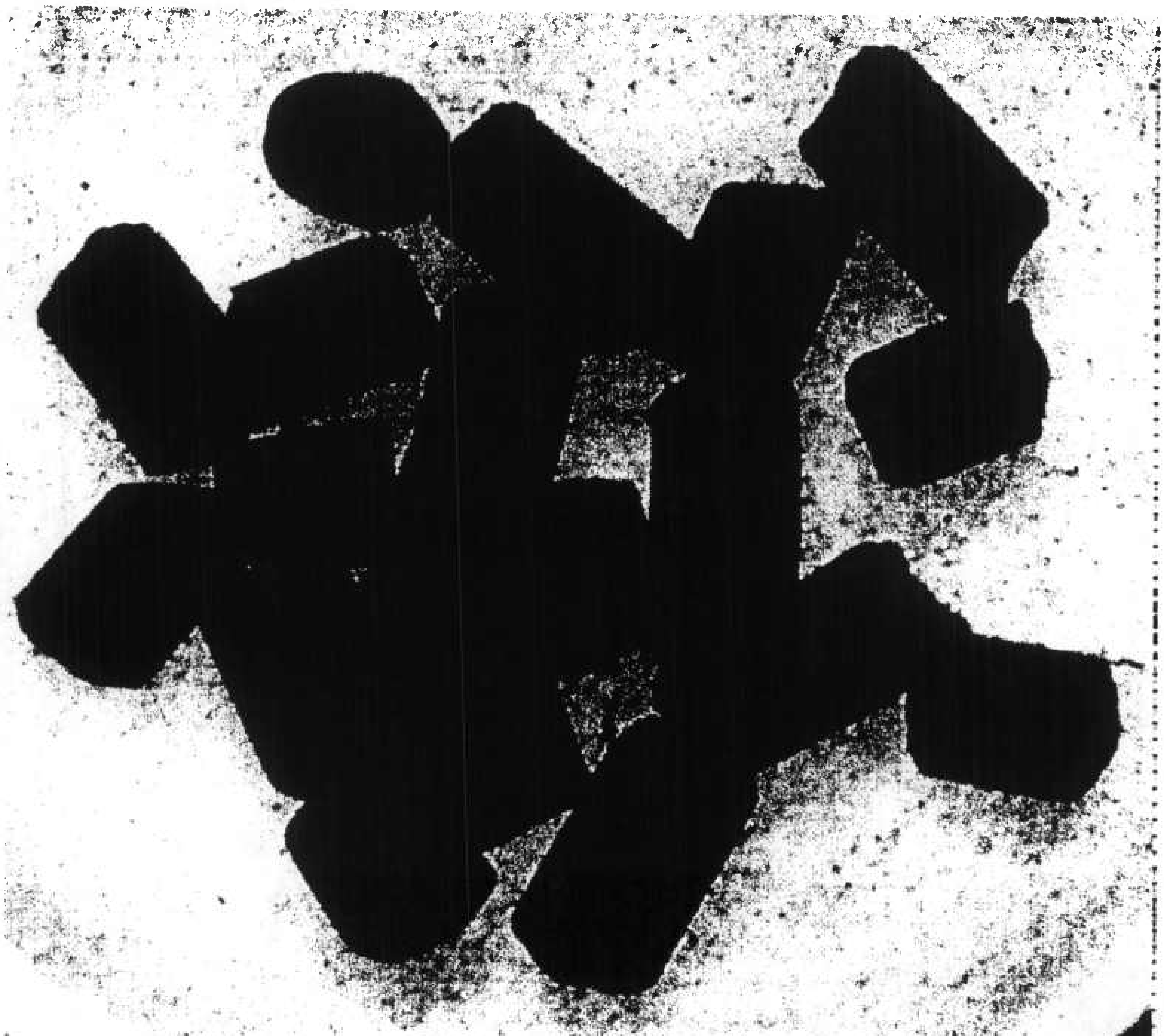


Table 10

LWT-99-42-2

CONFIDENTIAL

FULLER COMPANY
LIGHTWEIGHT TEST

Company: Enron **Location:** Houston, TX
Sample No. 990858C **Proj. #:** 9-22885-863-02-31 **Date** 8/04/99

FEED	PRODUCT	TEST WT. LOSS
B. Den.: 64.2 Lb/cf	B. Den.: 47.9 Lb/cf	Start Wt.: 146.5 g
Moisture 17.2 %	Vol. Exp.: 1:1.0	Final Wt.: 108.8 g
	Burn Temp. 1066 °C	Wt. Loss: 25.7 %

MIX DESIGN

1. 100.0 % Seattle Dredge Composite (-50 x 0) Lab # 990858C
2. ____ % ____ Lab # ____
3. ____ % ____ Lab # ____

LIGHTWEIGHT PROGRAM CM FURNACE

1. Start at 232° C (450° F)
2. Hold for 3. 0 minutes
3. Ramp to 315° C (600° F) in 6. 0 minutes
4. Hold for 7. 0 minutes
5. Ramp to 1066° C (1950° F) in 17. 0 minutes
6. Hold for 10. 0 minutes
7. Drop set point to 232°C (450° F)

TOTAL TEST TIME = 43 MINUTES

COMPRESSIVE STRENGTH

	VERTICAL				HORIZONTAL		
	LENGTH	WIDTH	POUNDS		LENGTH	WIDTH	POUNDS
1.	0.827	0.512	167	1.	0.503	0.732	235+
2.	0.748	0.538	230	2.	0.524	0.692	235+
3.	0.869	0.511	203	3.	0.508	0.707	235+
4.	0.880	0.520	235+	4.	0.506	0.717	235+
5.	0.958	0.522	235+	5.	0.519	0.745	235+
AVE.			214+	AVE.			235+

Remarks:
Pellets underburned . still red/brown in color . Pellets had small light specs in them. 10 cfh bottled air injected.

Table 11

LWT-99-42-3

CONFIDENTIAL

FULLER COMPANY
LIGHTWEIGHT TEST

Company: Enron **Location:** Houston, TX
Sample No. 990858C **Proj. #:** 9-22885-863-02-31 **Date** 8/04/99

FEED		PRODUCT		TEST WT. LOSS	
B. Den.:	64.3 Lb/cf	B. Den.:	42.2 Lb/cf	Start Wt.:	145.8 g
Moisture	17.2 %	Vol. Exp.:	1:1.1	Final Wt.:	108.1 g
		Burn Temp.	1079 °C	Wt. Loss:	25.9 %

MIX DESIGN

1. 100.0 % Seattle Dredge Composite (-50 x 0) Lab # 990858C
2. ______ % ______ Lab # ______
3. ______ % ______ Lab # ______

LIGHTWEIGHT PROGRAM CM FURNACE

1. Start at 232° C (450° F)
2. Hold for 3. 0 minutes
3. Ramp to 315° C (600° F) in 6. 0 minutes
4. Hold for 7. 0 minutes
5. Ramp to 1079° C (1975° F) in 17. 0 minutes
6. Hold for 10. 0 minutes
7. Drop set point to 232°C (450° F)

TOTAL TEST TIME = 43 MINUTES

COMPRESSIVE STRENGTH

	VERTICAL				HORIZONTAL		
	LENGTH	WIDTH	POUNDS		LENGTH	WIDTH	POUNDS
1.	0.938	0.520	235+	1.	0.516	0.848	235+
2.	0.866	0.554	180	2.	0.548	0.818	235+
3.	0.921	0.532	230	3.	0.526	0.828	235+
4.	0.805	0.524	235+	4.	0.520	0.777	235+
5.	0.898	0.538	235+	5.	0.535	0.791	235+
AVE.			223+	AVE.			235+

Remarks:
Pellets underburned . still red/brown in color . Pellets had small light specs in them. 10 cfh bottled air injected.

Table 12

LWT-99-42-1

FULLER COMPANY
LIGHTWEIGHT TEST

CONFIDENTIAL

Company: Enron **Location:** Houston , TX
Sample No. 990858C **Proj. #:** 9-22885-863-02-31 **Date** 8/04/99

FEED		PRODUCT		TEST WT. LOSS	
B. Den.:	66.2 Lb/cf	B. Den.:	39.2 Lb/cf	Start Wt.:	150.1 g
Moisture	17.2 %	Vol. Exp.:	1:1.3	Final Wt.:	111.2 g
		Burn Temp.	1093 °C	Wt. Loss:	25.9 %

MIX DESIGN

1. 100.0 % Seattle Dredge Composite (-50 x 0) Lab # 990858C
2. ______ % ______ Lab # ______
3. ______ % ______ Lab # ______

LIGHTWEIGHT PROGRAM CM FURNACE

1. Start at 232° C (450° F)
2. Hold for 3. 0 minutes
3. Ramp to 315° C (600° F) in 6. 0 minutes
4. Hold for 7. 0 minutes
5. Ramp to 1093° C (2000°F) in 17. 0 minutes
6. Hold for 10. 0 minutes
7. Drop set point to 232°C (450° F)

TOTAL TEST TIME = 43 MINUTES

COMPRESSIVE STRENGTH

	VERTICAL				HORIZONTAL		
	LENGTH	WIDTH	POUNDS		LENGTH	WIDTH	POUNDS
1.	0.898	0.584	235+	1.	0.612	0.951	235+
2.	0.933	0.617	150	2.	0.590	0.854	235+
3.	0.872	0.611	235+	3.	0.576	0.975	135
4.	0.880	0.585	235+	4.	0.593	1.054	235+
5.	0.925	0.625	235+	5.	0.607	0.897	235+
AVE.			218+	AVE.			215+

Remarks:
Pellets fused to dish and each other. Some bloating. 10 cfh bottled air injected.

Table 13

LWT-99-43-1

FULLER COMPANY
LIGHTWEIGHT TEST

CONFIDENTIAL

Company: Enron **Location:** Houston, TX
Sample No. 990858M **Proj. #:** 9-22885-863-02-31 **Date** 8/04/99

FEED	PRODUCT	TEST WT. LOSS
B. Den.: 70.3 Lb/cf	B. Den.: 44.9 Lb/cf	Start Wt.: 159.5 g
Moisture 14.1 %	Vol. Exp.: 1:1.1	Final Wt.: 121.9 g
	Burn Temp. 1079 °C	Wt. Loss: 23.6 %

MIX DESIGN

1. 99.5 % Seattle Dredge Composite (-50 x 0) Lab # 990858C
2. 0.5 % BC Oil Lab #
3. % Lab #

LIGHTWEIGHT PROGRAM CM FURNACE

1. Start at 232° C (450° F)
2. Hold for 3. 0 minutes
3. Ramp to 315° C (600° F) in 6. 0 minutes
4. Hold for 7. 0 minutes
5. Ramp to 1079° C (1975°F) in 17. 0 minutes
6. Hold for 10. 0 minutes
7. Drop set point to 232°C (450° F)

TOTAL TEST TIME = 43 MINUTES

COMPRESSIVE STRENGTH

	VERTICAL				HORIZONTAL		
	LENGTH	WIDTH	POUNDS		LENGTH	WIDTH	POUNDS
1.	0.910	0.560	235+	1.	0.537	0.712	235+
2.	0.850	0.528	235+	2.	0.525	0.742	235+
3.	0.784	0.520	235+	3.	0.542	0.826	235+
4.	0.903	0.555	235+	4.	0.550	0.827	235+
5.	0.821	0.540	235+	5.	0.525	0.932	235+
AVE.			235+	AVE.			235+

Remarks:
Feed was ground prior to pelletizing. Pellets somewhat bloated. Pellets had very small light specs in them. 10 cfh bottled air injected.

FIGURE 4
100% SEATTLE DREDGE
FIRED PRODUCT
1093°C / 39.2 LB/CF

CONFIDENTIAL

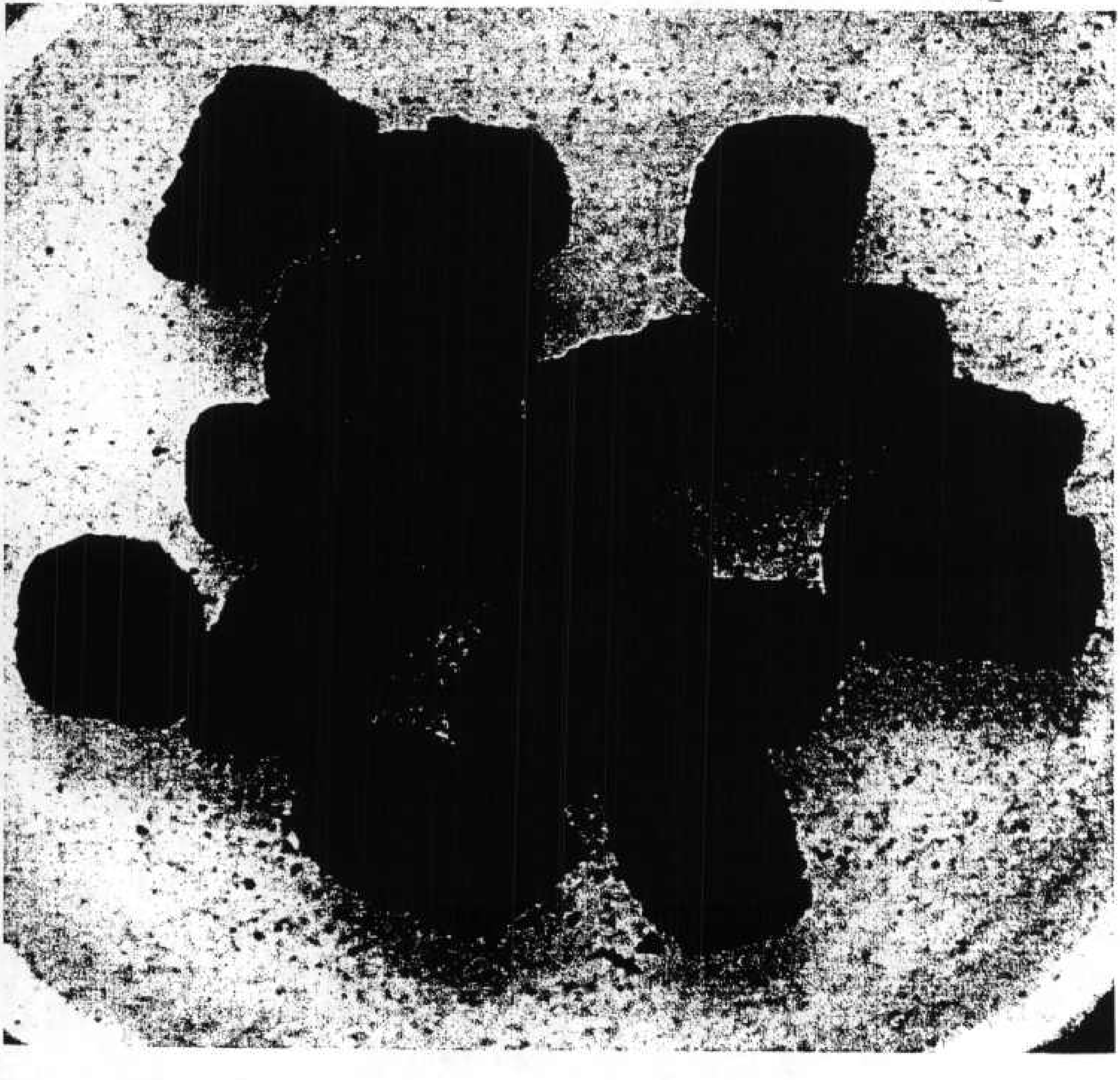


Table 14

LWT-99-44-4

CONFIDENTIAL

FULLER COMPANY
LIGHTWEIGHT TEST

Company: Enron **Location:** Houston , TX
Sample No. 990858M **Proj. #:** 9-22885-863-02-31 **Date** 8/13/99

FEED		**PRODUCT**		**TEST WT. LOSS**	
B. Den.:	70.6 Lb/cf	B. Den.:	42.2 Lb/cf	Start Wt.:	160.1 g
Moisture	14.0 %	Vol. Exp.:	1:1.3	Final Wt.:	126.4 g
		Burn Temp.	1051 °C	Wt. Loss:	21.0 %

MIX DESIGN

1.	50.0 %	Seattle Dredge Composite (-50 x 0)	Lab # 990858C
2.	50.0 %	Norlite Shale	Lab # 990392
3.	%		Lab #

LIGHTWEIGHT PROGRAM CM FURNACE

1. Start at 232° C (450° F)
2. Hold for 3. 0 minutes
3. Ramp to 315° C (600° F) in 6. 0 minutes
4. Hold for 7. 0 minutes
5. Ramp to 1051° C (1925° F) in 17. 0 minutes
6. Hold for 10. 0 minutes
7. Drop set point to 232°C (450° F)

TOTAL TEST TIME = 43 MINUTES

COMPRESSIVE STRENGTH

	VERTICAL				HORIZONTAL		
	LENGTH	WIDTH	POUNDS		LENGTH	WIDTH	POUNDS
1.	0.853	0.585	235+	1.	0.600	0.812	225
2.	1.062	0.581	235+	2.	0.582	1.004	235+
3.	1.131	0.573	235+	3.	0.614	0.963	235+
4.	0.862	0.614	235+	4.	0.578	1.164	235+
5.	0.974	0.598	235+	5.	0.586	0.875	235+
AVE.			235+	AVE.			233+

Remarks:
Feed was ground -100 mesh & extruded into ½" pellets. Pellets had some bloating . 10 cfh bottled air injected.

Table 15

LWT-99-44-3

FULLER COMPANY
LIGHTWEIGHT TEST

CONFIDENTIAL

Company: Enron **Location:** Houston, TX
Sample No. 990858M **Proj. #:** 9-22885-863-02-31 **Date** 8/13/99

FEED	**PRODUCT**	**TEST WT. LOSS**
B. Den.: 73.3 Lb/cf	B. Den.: 35.2 Lb/cf	Start Wt.: 166.2 g
Moisture 14.0 %	Vol. Exp.: 1:1.6	Final Wt.: 131.2 g
	Burn Temp. 1066 °C	Wt. Loss: 21.1 %

MIX DESIGN

1. 50.0 % Seattle Dredge Composite (-50 x 0) Lab # 990858C
2. 50.0 % Norlite Shale Lab # 990392
3. ______ % ______ Lab # ______

LIGHTWEIGHT PROGRAM CM FURNACE

1. Start at 232° C (450° F)
2. Hold for 3. 0 minutes
3. Ramp to 315° C (600° F) in 6. 0 minutes
4. Hold for 7. 0 minutes
5. Ramp to 1066° C (1950° F) in 17. 0 minutes
6. Hold for 10. 0 minutes
7. Drop set point to 232°C (450° F)

TOTAL TEST TIME = 43 MINUTES

COMPRESSIVE STRENGTH

	VERTICAL				HORIZONTAL		
	LENGTH	WIDTH	POUNDS		LENGTH	WIDTH	POUNDS
1.	0.858	0.590	235+	1.	0.638	0.935	183
2.	0.928	0.583	235+	2.	0.625	1.181	220
3.	1.107	0.602	235+	3.	0.652	1.150	150
4.	1.106	0.640	235+	4.	0.643	1.183	173
5.	0.992	0.554	218	5.	0.606	0.873	168
AVE.			232+	AVE.			179

Remarks:
Feed was ground –100 mesh & extruded into ½" pellets. Pellets were well bloated . 10 cfh bottled air injected.

Table 16

LWT-99-44-2

FULLER COMPANY
LIGHTWEIGHT TEST

CONFIDENTIAL

Company: Enron **Location:** Houston , TX
Sample No. 990858M **Proj. #:** 9-22885-863-02-31 **Date** 8/9/99

FEED		**PRODUCT**		**TEST WT. LOSS**	
B. Den.:	70.1 Lb/cf	B. Den.:	28.3 Lb/cf	Start Wt.:	159.1 g
Moisture	14.0 %	Vol. Exp.:	1:2.0	Final Wt.:	125.7 g
		Burn Temp.	1079 °C	Wt. Loss:	21.0 %

MIX DESIGN

1. 50.0 % Seattle Dredge Composite (-50 x 0) Lab # 990858C
2. 50.0 % Norlite Shale Lab # 990392
3. ____ % ____ Lab # ____

LIGHTWEIGHT PROGRAM CM FURNACE

1. Start at 232° C (450° F)
2. Hold for 3. 0 minutes
3. Ramp to 315° C (600° F) in 6. 0 minutes
4. Hold for 7. 0 minutes
5. Ramp to 1079° C (1975° F) in 17. 0 minutes
6. Hold for 10. 0 minutes
7. Drop set point to 232°C (450° F)

TOTAL TEST TIME = 43 MINUTES

COMPRESSIVE STRENGTH

	VERTICAL				HORIZONTAL		
	LENGTH	WIDTH	POUNDS		LENGTH	WIDTH	POUNDS
1.	0.995	0.652	190	1.	0.619	1.460	235+
2.	1.106	0.706	235+	2.	0.628	1.191	170
3.	1.107	0.660	235+	3.	0.574	1.086	200
4.	0.990	0.674	220	4.	0.668	1.225	235+
5.	1.101	0.648	230	5.	0.673	1.288	235+
AVE.			222+	AVE.			215+

Remarks:
Feed was ground -100 mesh & extruded into ½" pellets. Pellets were well bloated . 10 cfh bottled air injected.

LWT-99-44-1

FULLER COMPANY
LIGHTWEIGHT TEST

CONFIDENTIAL

Company: Enron **Location:** Houston, TX
Sample No. 990858M **Proj. #:** 9-22885-863-02-31 **Date** 8/9/99

FEED	PRODUCT	TEST WT. LOSS
B. Den.: 72.6 Lb/cf	B. Den.: 25.1 Lb/cf	Start Wt.: 164.7 g
Moisture 14.0 %	Vol. Exp.: 1:2.4	Final Wt.: 129.3 g
	Burn Temp. 1093 °C	Wt. Loss: 21.5 %

MIX DESIGN

1.	50.0 %	Seattle Dredge Composite (-50 x 0)	Lab # 990858C
2.	50.0 %	Norlite Shale	Lab # 990392
3.	%		Lab #

LIGHTWEIGHT PROGRAM CM FURNACE

1. Start at 232° C (450° F)
2. Hold for 3. 0 minutes
3. Ramp to 315° C (600° F) in 6. 0 minutes
4. Hold for 7. 0 minutes
5. Ramp to 1093° C (2000° F) in 17. 0 minutes
6. Hold for 10. 0 minutes
7. Drop set point to 232°C (450° F)

TOTAL TEST TIME = 43 MINUTES

COMPRESSIVE STRENGTH

	VERTICAL				HORIZONTAL		
	LENGTH	WIDTH	POUNDS		LENGTH	WIDTH	POUNDS
1.	1.430	0.785	235+	1.	0.718	1.279	210
2.	1.229	0.720	208	2.	0.710	1.516	145
3.	1.261	0.771	220	3.	0.722	1.364	205
4.	1.195	0.785	205	4.	0.671	1.421	190
5.	1.273	0.739	170	5.	0.650	1.521	220
AVE.			207+	AVE.			194

Remarks:
Feed was ground -100 mesh & extruded into ½" pellets. Pellets were over bloated 10 cfh bottled air injected.

FIGURE 5
50% SEATTLE DREDGE + 50% NORLITE SHALE
FIRED PRODUCT
1093°C / 25.1 LB/CF

Table 18

LWT-99-46-5

FULLER COMPANY
LIGHTWEIGHT TEST CONFIDENTIAL

Company: Enron **Location:** Houston , TX
Sample No. 990858M2 **Proj. #:** 9-22885-863-02-31 **Date** 8/12/99

FEED		PRODUCT		TEST WT. LOSS	
B. Den.:	62.4 Lb/cf	B. Den.:	42.9 Lb/cf	Start Wt.:	141.5 g
Moisture	19.8 %	Vol. Exp.:	1:1.02	Final Wt.:	104.3 g
		Burn Temp.	1051 °C	Wt. Loss:	26.3 %

MIX DESIGN

1. 50.0 % Seattle Dredge Composite (-50 x 0) Lab # 990858C
2. 50.0 % Empire Shale Lab # 990782
3. ____ % ____ Lab # ____

LIGHTWEIGHT PROGRAM CM FURNACE

1. Start at 232° C (450° F)
2. Hold for 3. 0 minutes
3. Ramp to 315° C (600° F) in 6. 0 minutes
4. Hold for 7. 0 minutes
5. Ramp to 1051° C (1925° F) in 17. 0 minutes
6. Hold for 10. 0 minutes
7. Drop set point to 232°C (450° F)

TOTAL TEST TIME = 43 MINUTES

COMPRESSIVE STRENGTH

	VERTICAL				HORIZONTAL		
	LENGTH	WIDTH	POUNDS		LENGTH	WIDTH	POUNDS
1.	0.719	0.552	230	1.	0.556	0.831	235+
2.	0.750	0.557	218	2.	0.574	0.856	230
3.	0.706	0.570	165	3.	0.527	0.775	235+
4.	0.710	0.555	203	4.	0.540	0.665	235+
5.	0.757	0.585	166	5.	0.528	0.782	235+
AVE.			196	AVE.			234+

Remarks:
Re-extruded pellets to lower moisture from 21.23% in test 99-46-1. Little bloating. 10 cfh bottled air injected.

Table 19

LWT-99-46-3

FULLER COMPANY
LIGHTWEIGHT TEST

CONFIDENTIAL

Company: Enron **Location:** Houston, TX
Sample No. 990858M2 **Proj. #:** 9-22885-863-02-31 **Date** 8/12/99

FEED		**PRODUCT**		**TEST WT. LOSS**	
B. Den.:	67.7 Lb/cf	B. Den.:	34.9 Lb/cf	Start Wt.:	153.5 g
Moisture	19.8 %	Vol. Exp.:	1:1.4	Final Wt.:	112.8 g
		Burn Temp.	1066 °C	Wt. Loss:	26.5 %

MIX DESIGN

1.	50.0 %	Seattle Dredge Composite (-50 x 0)	Lab # 990858C
2.	50.0 %	Empire Shale	Lab # 990782
3.	%		Lab #

LIGHTWEIGHT PROGRAM CM FURNACE

1. Start at 232° C (450° F)
2. Hold for 3. 0 minutes
3. Ramp to 315° C (600° F) in 6. 0 minutes
4. Hold for 7. 0 minutes
5. Ramp to 1066° C (1950° F) in 17. 0 minutes
6. Hold for 10. 0 minutes
7. Drop set point to 232°C (450° F)

TOTAL TEST TIME = 43 MINUTES

COMPRESSIVE STRENGTH

	VERTICAL				HORIZONTAL		
	LENGTH	**WIDTH**	**POUNDS**		**LENGTH**	**WIDTH**	**POUNDS**
1.	0.867	0.614	235+	1.	0.621	0.915	213
2.	1.036	0.543	175	2.	0.632	0.865	200
3.	0.974	0.562	160	3.	0.582	0.886	165
4.	0.991	0.560	220	4.	0.580	0.818	230
5.	0.821	0.520	235+	5.	0.595	0.758	225
AVE.			205+	AVE.			206

Remarks:
Re-extruded pellets to lower moisture from 21.23% in test 99-46-1. Decent bloating, no sticking. 10 cfh bottled air injected.

LWT-99-46-2

FULLER COMPANY
LIGHTWEIGHT TEST CONFIDENTIAL

Company: Enron **Location:** Houston, TX
Sample No. 990858M2 **Proj. #:** 9-22885-863-02-31 **Date** 8/11/99

FEED		**PRODUCT**		**TEST WT. LOSS**	
B. Den.:	61.4 Lb/cf	B. Den.:	28.0 Lb/cf	Start Wt.:	139.4 g
Moisture	19.8 %	Vol. Exp.:	1:1.6	Final Wt.:	102.3 g
		Burn Temp.	1093 °C	Wt. Loss:	26.6 %

MIX DESIGN

1. 50.0 % Seattle Dredge Composite (-50 x 0) Lab # 990858C
2. 50.0 % Empire Shale Lab # 990782
3. ______ % ______ Lab # ______

LIGHTWEIGHT PROGRAM CM FURNACE

1. Start at 232° C (450° F)
2. Hold for 3. 0 minutes
3. Ramp to 315° C (600° F) in 6. 0 minutes
4. Hold for 7. 0 minutes
5. Ramp to 1093° C (2000° F) in 17. 0 minutes
6. Hold for 10. 0 minutes
7. Drop set point to 232°C (450° F)

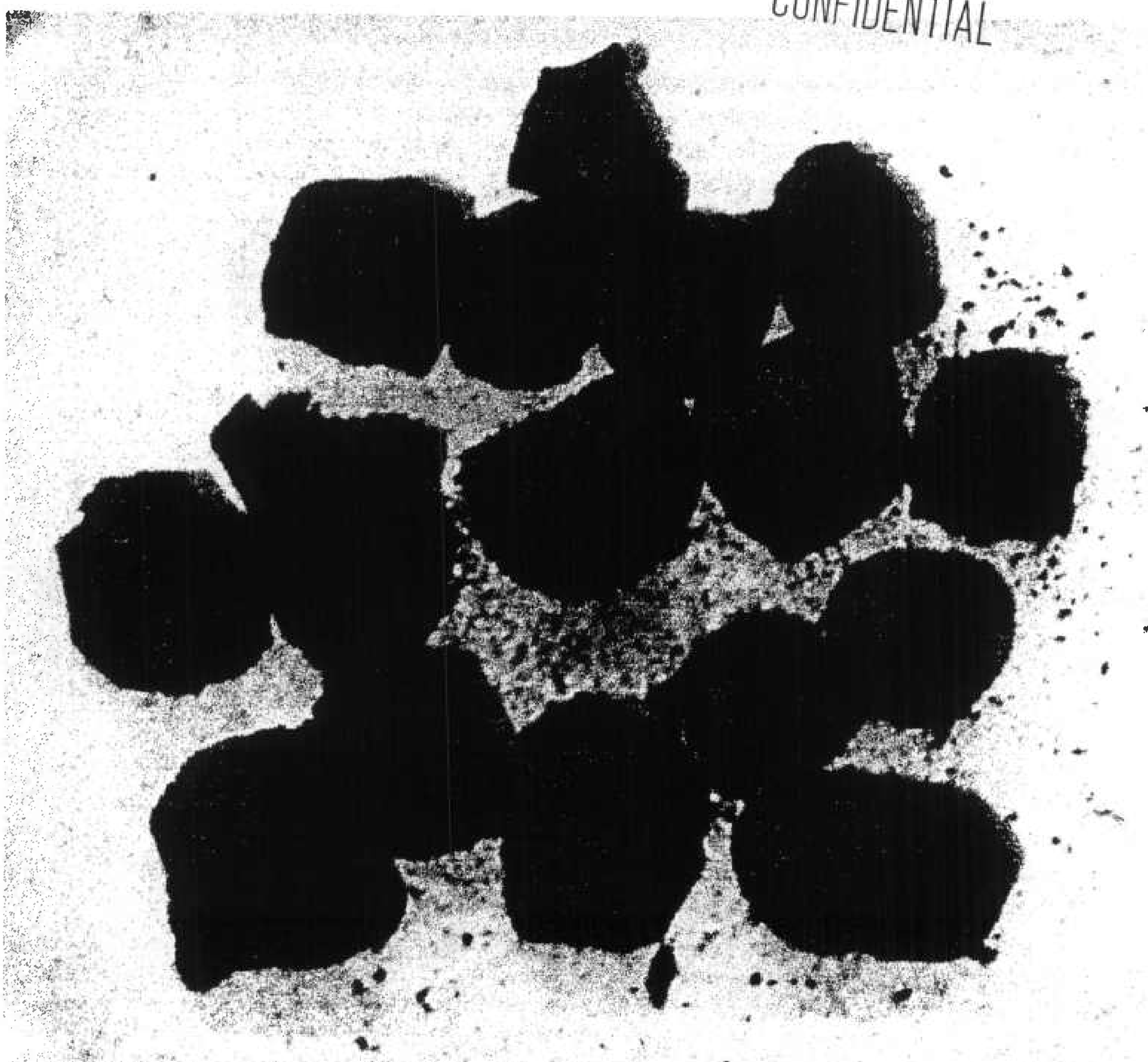
TOTAL TEST TIME = 43 MINUTES

COMPRESSIVE STRENGTH

	VERTICAL				HORIZONTAL		
	LENGTH	WIDTH	POUNDS		LENGTH	WIDTH	POUNDS
1.	0.968	0.538	165	1.	0.550	0.844	153
2.	0.992	0.584	210	2.	0.675	0.830	160
3.	1.025	0.648	150	3.	0.652	0.858	235+
4.	0.828	0.656	150	4.	0.603	0.998	100
5.	0.975	0.540	120	5.	0.624	0.918	140
AVE.			159	AVE.			157+

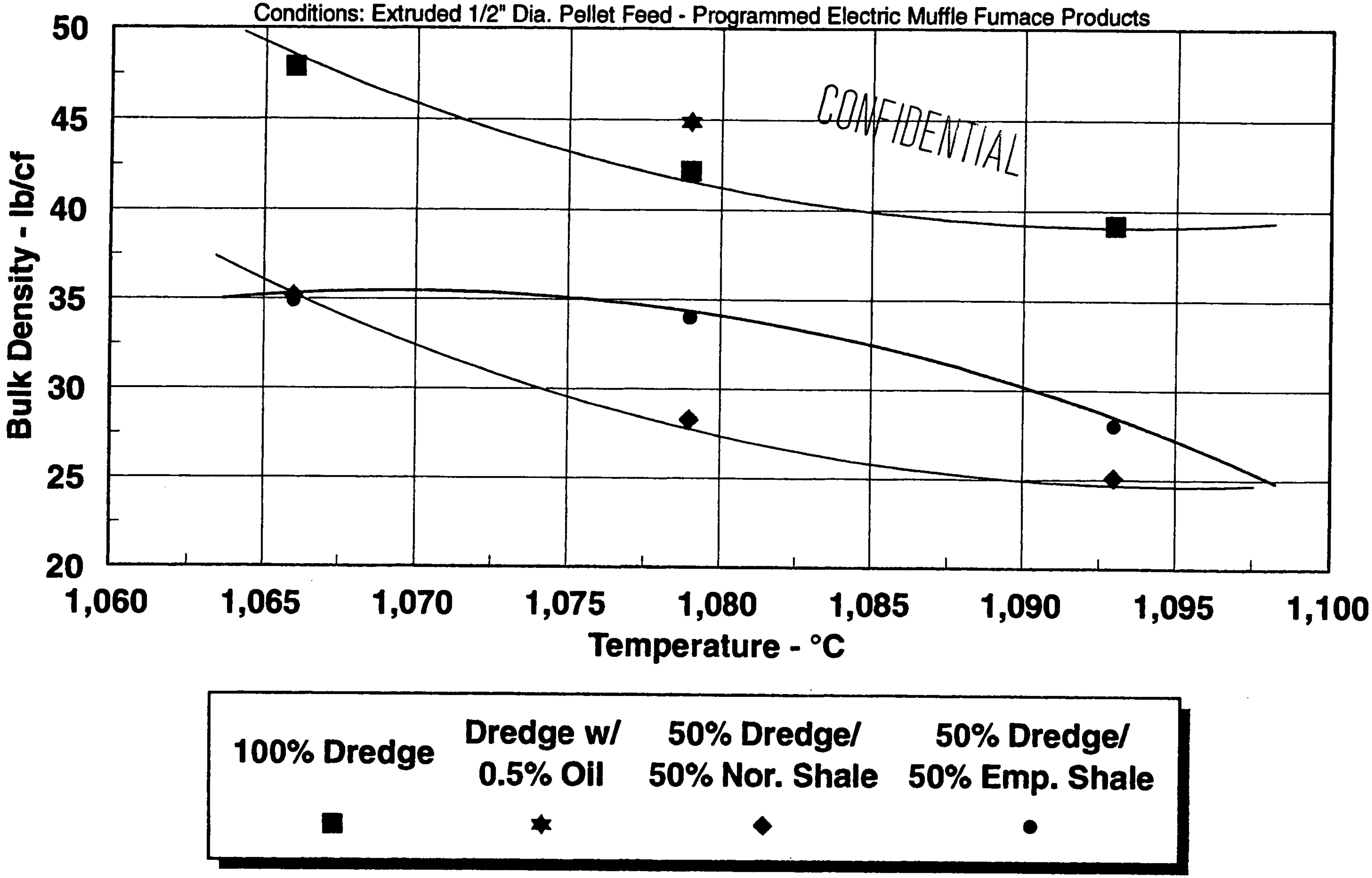
Remarks:
Re-extruded pellets to lower moisture from 21.23% in test 99-46-1. Decent bloating. 10 cfh bottled air injected.

FIGURE 6
50% SEATTLE DREDGE + 50% EMPIRE SHALE
FIRED PRODUCT
1093°C / 28 LB/CF



FIGU 7

Enron Lightweight Aggregate Evaluation
Seattle Dredge Samples
Temperature vs. Bulk Density



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\1899\ENRON\PHASE 1\SEATTLE\TEMP-BD.PRE

FIGURE 1

Enron Lightweight Aggregate Evaluation
Seattle Dredge Sample
Temperature vs. Volume Expansion

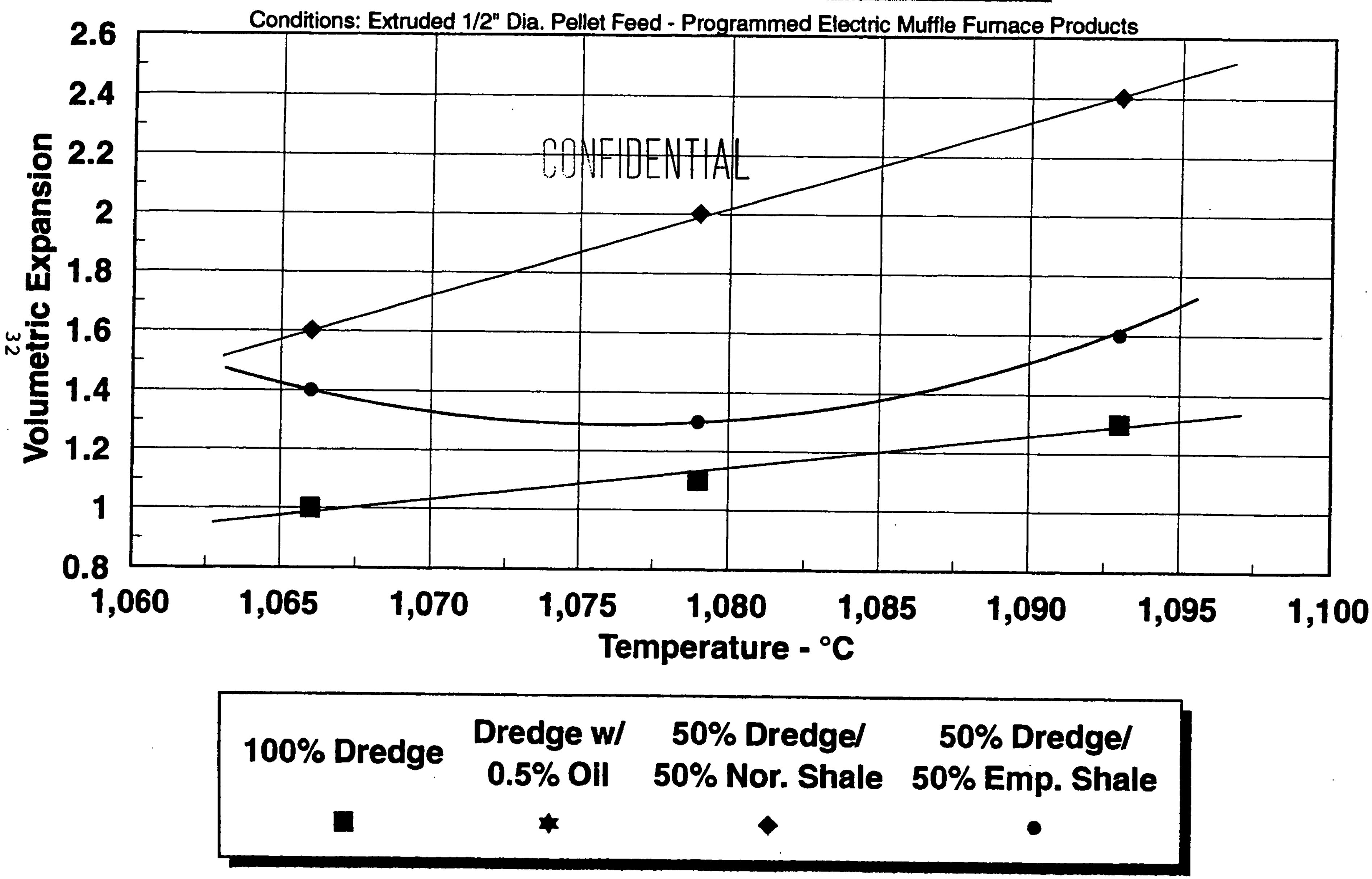

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Table 21

SUMMARY RESULTS OF ALL TEST BURNS

Sample		Bulk Density	Nol Expansion %	Compressive Strength lbs Vertical	Compressive Strength lbs Horizontal
50M x 0 Composite	1950° F	47.9	0	214 +	235 +
50M x 0 Composite	1975° F	42.2	10	223 +	235 +
50M x 0 Composite	2000° F	39.2	30	218 +	215 +
50/MXD Composite/w0.5% BC oil	1975° F	44.9	10	235 +	235 +
50/50 Mix NY Shale	1925° F	42.2	30	235 +	235 +
50/50 Mix NY Shale	1950° F	35.2	60	232 +	179 +
50/50 Mix NY Shale	1975° F	28.3	100	222 +	215 +
50/50 Mix NY Shale	2000° F	25.1	140	207 +	194 +
50/50 Mix Oregon Shale	1925° F	42.9	196	234 +	234 +
50/50 Mix Oregon Shale	1950° F	34.9		205 +	206 +
50/50 Mix Oregon Shale	1975° F	28.0		159 +	157 +

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Table 22

LWA COMMERCIAL PLANT PARTICLE CRUSHING STRENGTH
(For Comparison Only)

Plant	Bulk Density lbs/cu ft	Particle Crush Strength* (lbs)	End Use
A	56.9	131	Structural and Masonry Block
B	50.7	177 (Extrusions)	Masonry Block
C	41.0	197	Structural
D	34.1	128	Masonry Block
E	45.0	86 (Rolled Pellets)	Geo Thermal (Fly Ash Product)
F	34.1	120	Surface Treatment
G	41.7	122	Masonry Block
H	47.5	197	Structural and Masonry Block
I	38.2	183	Structural and Masonry Block
J	35.0	165	Structural and Masonry Block

* **Average of 5 Particles**

Emission Testing

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In order to evaluate the potential emission of combustion products emitted from the feed material a controlled furnace and emission measurement test was conducted on the Seattle 50 mesh x 0 composite dredge and the composite dredge combined with 50% of shale obtained from Timber, OR. The results obtained are illustrated in **Figures** 8 & 9.

Based on these tests it is shown that the dredge material will generate a high level of CO, & THC starting at 250° C (480° F). It also indicated that SO_2 emissions take place at two temperature levels, 150ppm peak at 300° C (575° F) and a secondary peak of 75ppm at 850° C (1562° F).

The THC, CO, and CH_4 levels (THC peak 180ppm @ 330° C (626° F), CO peak of 315ppm, @350° C (662° F), and CH_4 peak of 40ppm @420° C (778° F) are primarily due to the residue organic tree bark noted in the material. The presence of sea shells seen in the full composite seem to have been removed by the 50 mesh separation based on a lack of a CO_2 peak in the 50 x 0 composite test.

The effect of the addition of a shale from Timber, OR, in a 50/50 mix on the material emissions can be seen by comparing the two figures given. The shale addition reduce the THC peak from 180ppm to 55ppm, CO from the 315ppm to 195ppm and CH_4 from 40ppm to 17ppm, almost a 50% reduction of each.

The levels of SO_2 present is affected the most in the 50/50 mix since the shale is known to have a sulfur content. The two sulfur peaks has the 120ppm peak increased to 150ppm is and the secondary peak from 75ppm to 110ppm.

These results indicate that any system processing these materials may need an after burner to control the THC, CO and CH_4 emission to meet local codes. It may also be necessary to have a SO_2 scrubber system depending on local codes at any potential plant sites. This may be necessary for all LWA plants based on the new MACT standards just signed by EPA.

It should be pointed out that these results do not include emissions based on the fuel used to process these materials in the rotary kiln system. Therefore, it is very important that emission data be obtained from complete pilot kiln system to better predict the potential emission from a commercial system.

In order to determine the burn out potential a DTA/TGA analysis was made (**Figure** 10). This indicates that the THC, CO and CH_4 starts to burn out at 200° C (392° F) and levels off at 600° C (1112° F), therefore any pre-burn out should be made at 700° C (1292° F) in order not to generate emission from the burn out system used.

FIGURE 9

ENRON, TX

Extruded Pellets

(Seattle Composite)

6 August 99

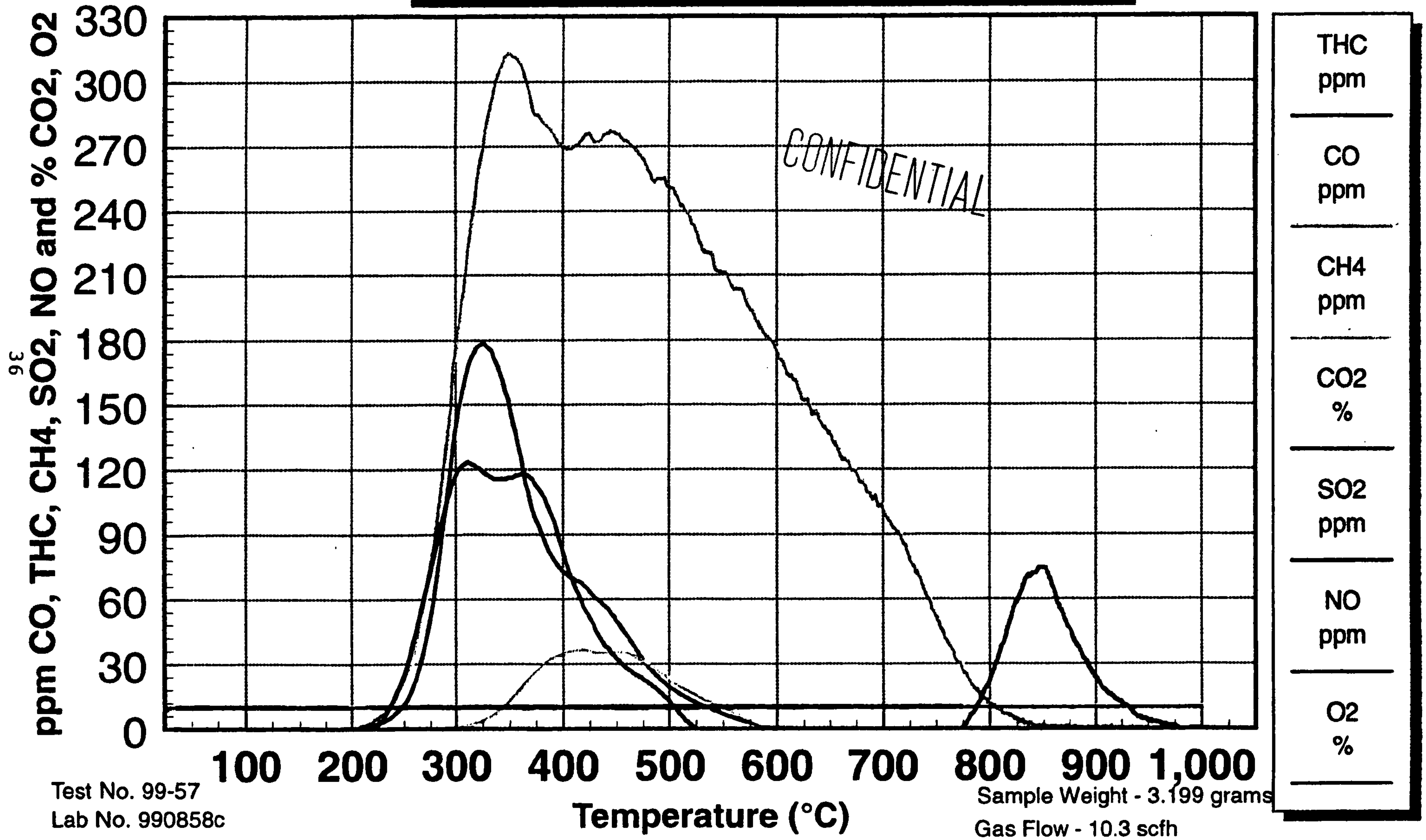
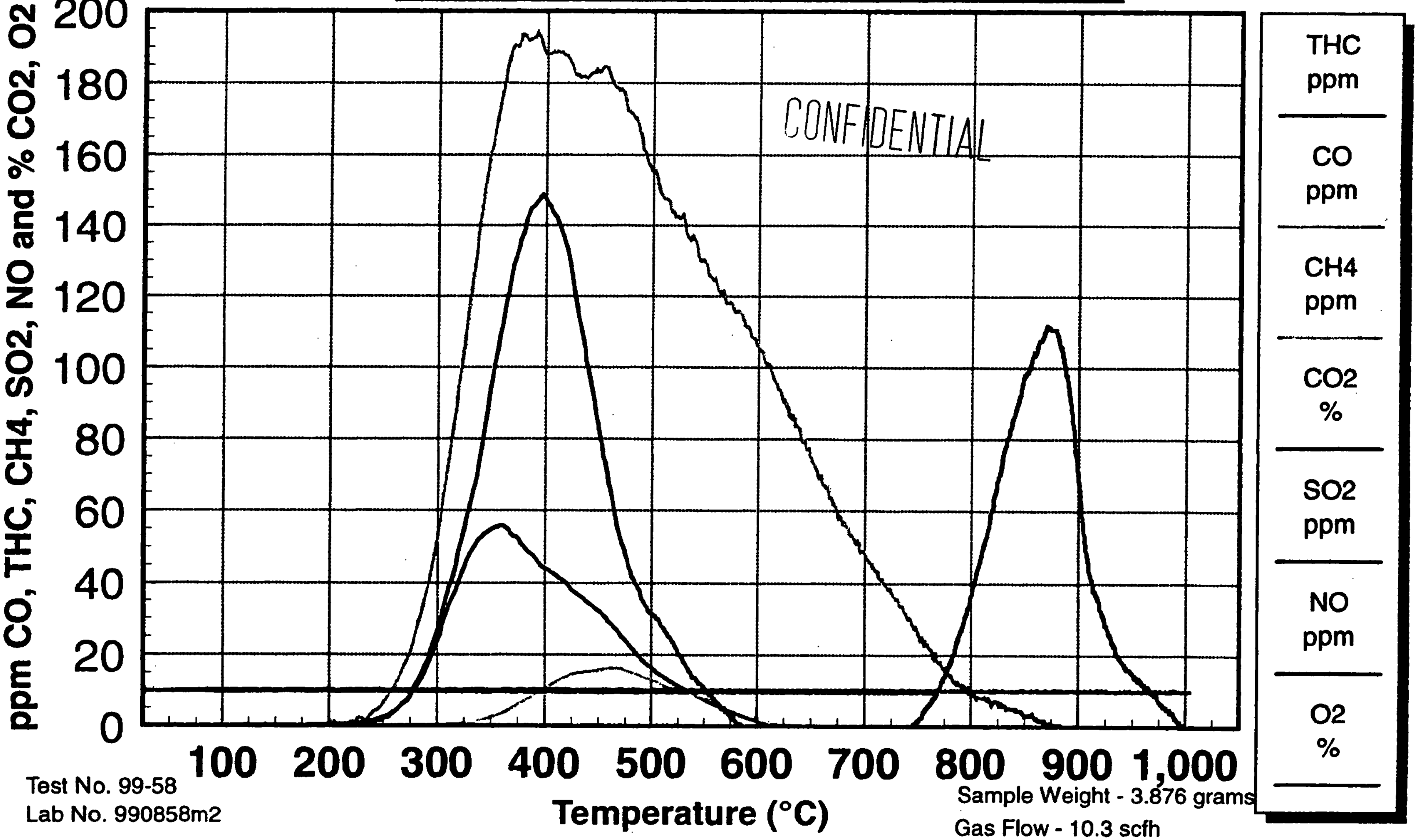


FIGURE 10

ENRON, TX

50% Seattle Dredge Composite / 50% Empire Shale

12 August 99



Test No. 99-58
Lab No. 990858m2

Sample Weight - 3.876 grams
Gas Flow - 10.3 scfh

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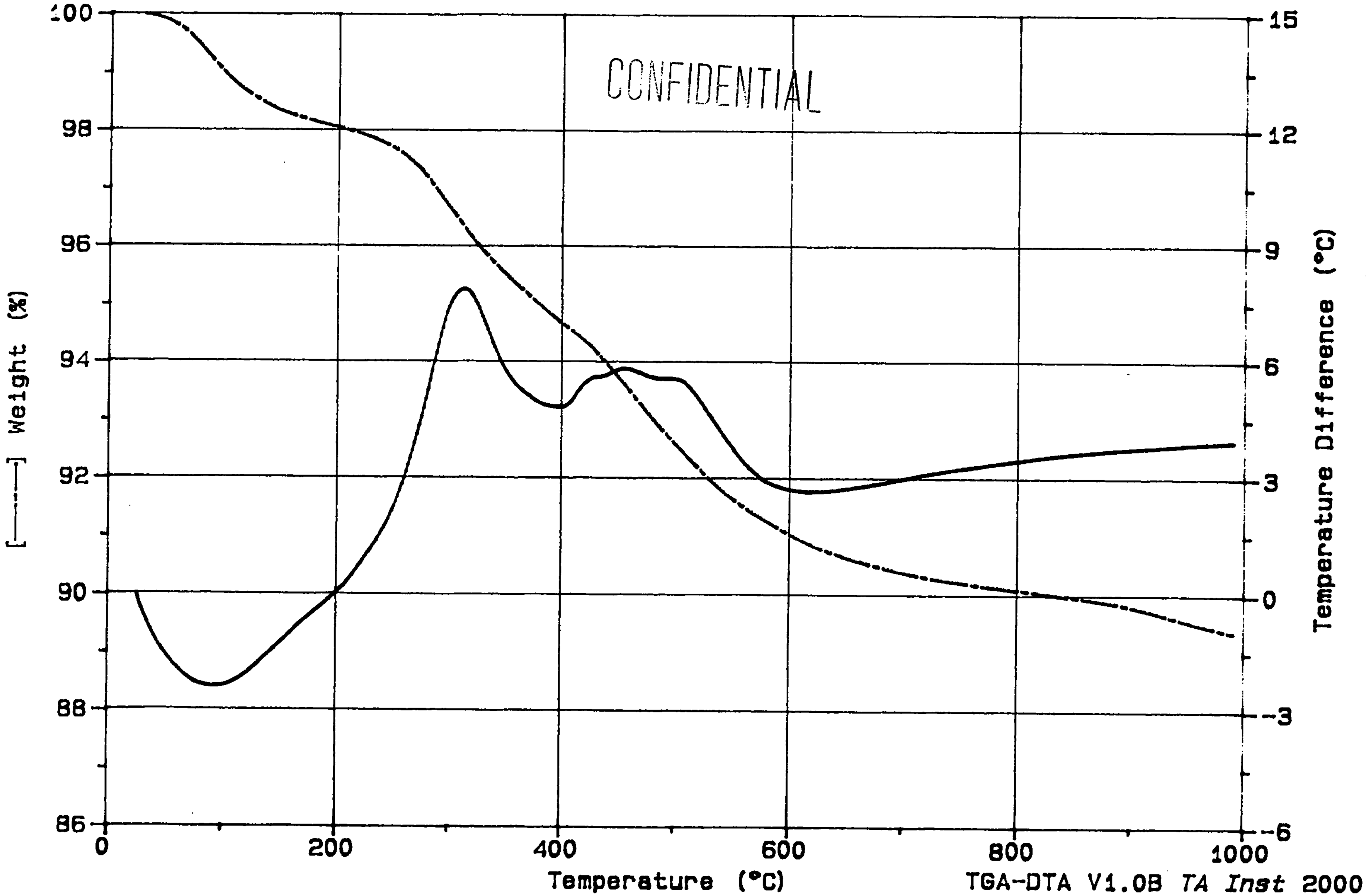
FIGURE 11

Sample: ENRON- SEATTLE DREDGINGS
Size: 74.8728 mg
Method: RAMP RT-1000°C @ 20°C/MIN
Comment: 100 CC/MIN PURGE GAS; AIR

TGA-DTA

File: C:990858C.002
Operator: SJE
Run Date: 10-Aug-99 13:12



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Recommendations and Conclusions

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Based on the results of the preliminary bench scale evaluation the following recommendations and conclusions are made:

1. The composite dredge material contains a percentage of organic waste, tree bark and shell fragments, which will require a separation at 50 mesh to remove most of these contaminates. Approximately 76% dredge would be recovered in the -50m x 0 fraction for producing LWA.

2. The chemical analyses of the -50 mesh fraction indicates the material has the potential to produce LWA.

3. The presence of a high level of organic carbon (3%) in the 50 mesh x 0 fraction seems to destroy the bloating capability of the material when fired as an extruded ½ "⌀ pellet.

4. The problem of the high organic carbon can be solved by diluting the 50 mesh x 0 material with a ground bloatable shale or clay. Two shales were used in a 50/50 mixture with the dredge material to produce what looks to be a quality product.

5. A product can be produced between 28 to 42 lbs/cuft from extruded ½" ⌀ pellets made up of 50/50 mixture with a shale obtained from an area near Seattle in a temperature range of 1950 to 2000° F. Additional testing using less shale may be possible if a new shale sample, which is less weathered then the sample tested and additional dredge material is obtained.

6. Volume expansion obtained from the 50/50 mix product using the locale shale was 60% at 2000° F.

7. Emission test on materials tested only indicate there my be a need to have both an after burner system and a sulfur control scrubber system in the commercial installation.

8. Compressive strength tests made on the 50/50 mix product pellets indicate a product suitable for all end LWA uses should be possible based on comparison with similar test results obtained on commercial products currently marketed. This is not an offical ASTM test, but one used by Fuller Company R&D for indications of potential strength properties.

9. It is recommended that a full scale pilot rotary kiln test be conducted to produce enough product for full ASTM evaluation. It would also allow for emission data for permitting purposes.

SAMPLE JARS RECEIVED
JAR MARKINGS

Fuller R&D ID NO.		DRM #		DATE	HOURS	1 QT. JARS	WEIGHT (LBS)
990858	AN-SC-73	3	5163	10-28-98	0929	1	0.5.
990859	AN-SC-80	3	5215	10-28-98	1542.	1	0.37
990860	AN-SS-36	3	5202	10-28-98	1420	1	0.62
990861	AN-SC-72	3	5150	10-28-98	0841	1	0.5
990862	AN-SC-71	3	5137	10-27-98	1455	1	0.5
990863	AN-SC-82	3	5232	10-29-98	0923	1	0.5
990864	AN-SC-78	3	5189	10-28-98	1150	1	0.5
990865	AN-SC-72	3	5148	10-28-98	0841	1	0.69
990866	AN-SC-80	3	5219	10-28-98		1	0.62
990867	AN-SC-77	3	5176	10-28-98	1032	1	0.5
990868	AN-SC-37	3	5262	10-29-98	1115	1	0.56
990869	AN-SC-81	3	5249	10-28-98	1025	1	0.5
990870	AN-SC-81	3	5247	10-27-98	1025	1	0.69
990871	AN-SC-77	3	5174	10-28-98	1032	1	0.62
990872	AN-SC-78	3	5187	10-28-98	1150	1	0.62
990873	AN-SC-82	3	5230	10-29-98	0923	1	0.62
990874	AN-SS-36	3	5200	10-28-98	1420	1	1.0
990875	AN-SC-80	3	5217	10-28-98	1542	1	0.5
990876	AN-SS-37	3	5260	10-29-98	1115	1	0.81
990877	AN-SC-71	3	5135	10-28-98	1455	1	0.56
990878	AN-SC-73	3	5161	10-28-98	0929	1	0.62
990879	-AN-SC-80	3	5213	10-28-98	1542	1	0.5
990880	AN-SS-37	3	5252	10-29-98	1115	1	
990881	AN-SS-84	#3	5071	10-29-98	0920	1	
990882	AN-SC-80	3	5204	10-27-98	1542	1	2.12

SAMPLE JARS RECEIVED
JAR MARKINGS

990883	AN-SC-36	3	5190	10-28-98	1420	1	4.37
990884	AN-SS-306	3	5025	10-26-98	1508	1	2.37
990885	AN-SS-45	3	5082	10-27-98	1117	1	3.5
990886	CR-22	CARR INLET		10-27-98	1213	1	4.31
990887	AN-SC-82	WWA #3	5220	10-29-98	0923	1	3.25
990888	CR-22	CARR INLET		10-29-98	1243	1	2.25
990889	AN-SC-71	WWA #3	5125	10-29-98	1455	1	3.37
990890	AN-SC-84	WWA #3	5069	10-27-98	0920	1	3.5
990891	CR-22	CARR INLET		10-29-98	1243	1	4.62
990892	AN-SC-70	WWA #3	5110	10-27-98	1404	1	1.56
990893	AN-SC-71	WWA #3	5127	10-29-98	1455	1	2.12
990894	CR-10			10-29-98	1102	1	2.31
990895	AN-SS-45		5083	10-27-98	1117	1	2.06
990896	AN-SS-36	WWA #3	5191	10-28-98	1420	1	2.12
990897	AN-SS-303	SR	5038	10-26-98	1550	1	2.0
990898	AN-SS-47	WWA #3	5097	10-27-98	1222	1	2.0
990899	AN-SC-80	WWA #3	5203	10-28-98	1542	1	3.37
990900	AN-SS-301		5058	10-26-98	1740	1	3.25
990901	AN-SC-73	WWA #3	5151	10-28-98	0929	1	3.37
990902	AN-SS-37	WWA #3	5250	10-29-98	1115	1	3.75
990903	AN-SS-47	WWA #3	5095	10-27-98	1222	1	4:06
990904	AN-SS-47	SR	5036	10-26-98	1550	1	3.37
990905	AN-SS-305	SR	5012	10-26-98	1147	1	3.19
990906	AN-SS-304	SR	5001	10-26-98	1032	1	3.75
990907	AN-SC-70	WWA #3	5108	10-27-98	1404	1	3.44
990908	AN-SC-72	WWA #3	5138	10-28-98	0841	1	3.5

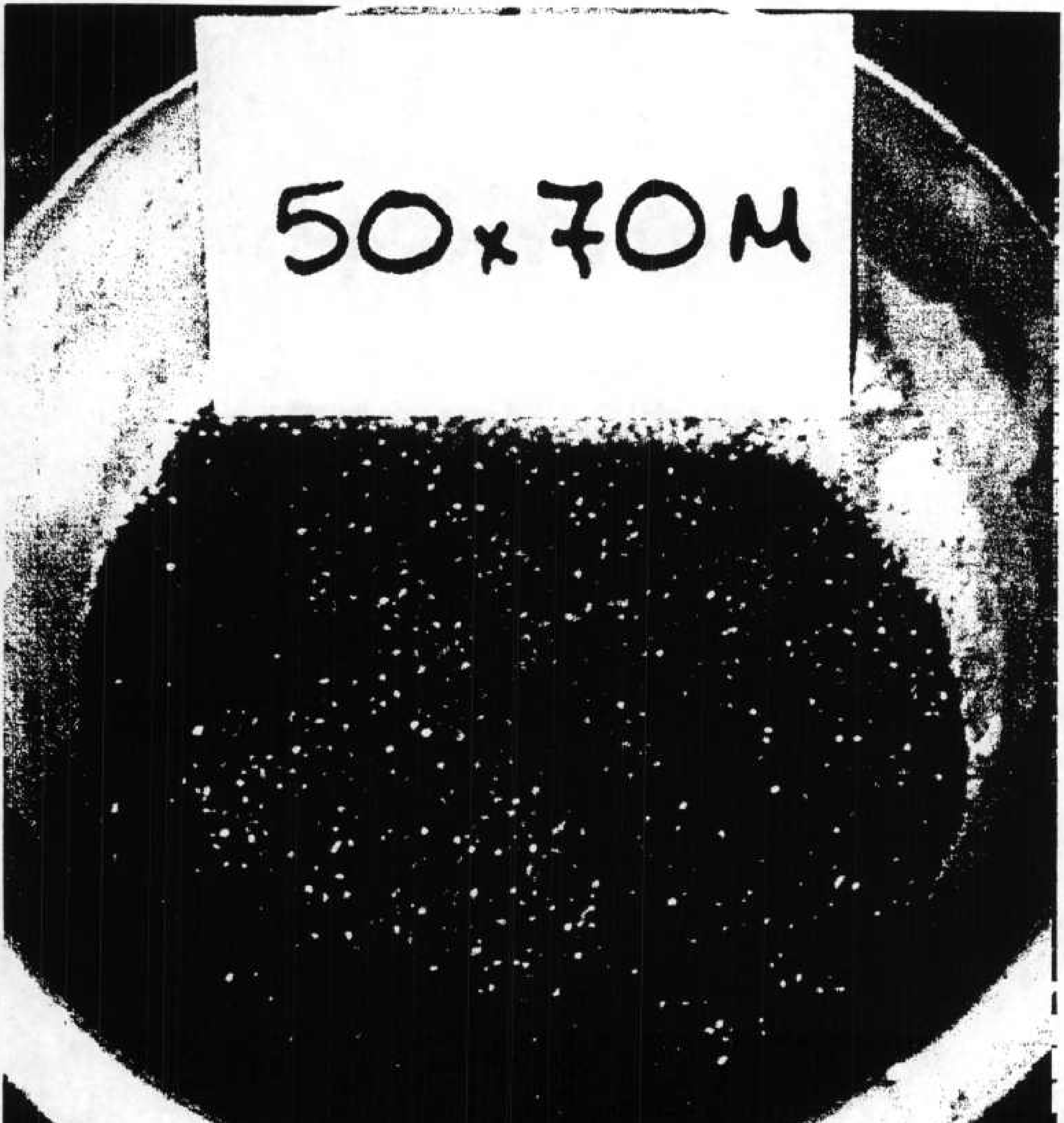
SAMPLE JARS RECEIVED
JAR MARKINGS

990909	CR-10	CARR INLET		10-28-98	1102	1	4.12
990910	AN-SS-302	SR	5048	10-26-98	1711	1	1.87
990911	AN-SS-302	SR	5047	10-26-98	1711	1	3.5
990912	AN-SS-301	SR	5059	10-26-98	1740	1	2.0
990913	AN-SS-305	SR	5015	10-26-98	1147	1	2.0
990914	AN-SS-304	SR	5002	10-26-98	1032	1	2.37
990915	AN-SS-306	SR	5024	10-26-98	1508	1	3.62
990916	CR 23W	CARR INLET		10-29-98	1426	1	4.69
990917	CR 10	CARR INLET		10-29-98	1102	1	3.5
990918	AN-SC-78	WWA #3	5197	10-28-98	1150	1	3.0
990919	AN-SC-73	WWA #3	5153	0929	0929	1	1.69
990920	AN-SC-77	WWA #3	5166	1032	1032	1	1.31
990921	AN-SC-77	WWA #3	5164	1150	1032	1	3.47
990922	AN-SC-78	WWA #3	5178	0923	1150	1	2.12
990923	AN-SC-82	WWA #3	5222	1025	0923	1	2.12
990924	AN-SC-81	WWA #3	5237	1222	1025	1	3.44
990925	AN-SS-47	WWA #3		0841	1222	1	4.37
990926	AN-SC-72	WWA #3	5140		0841	1	2.19

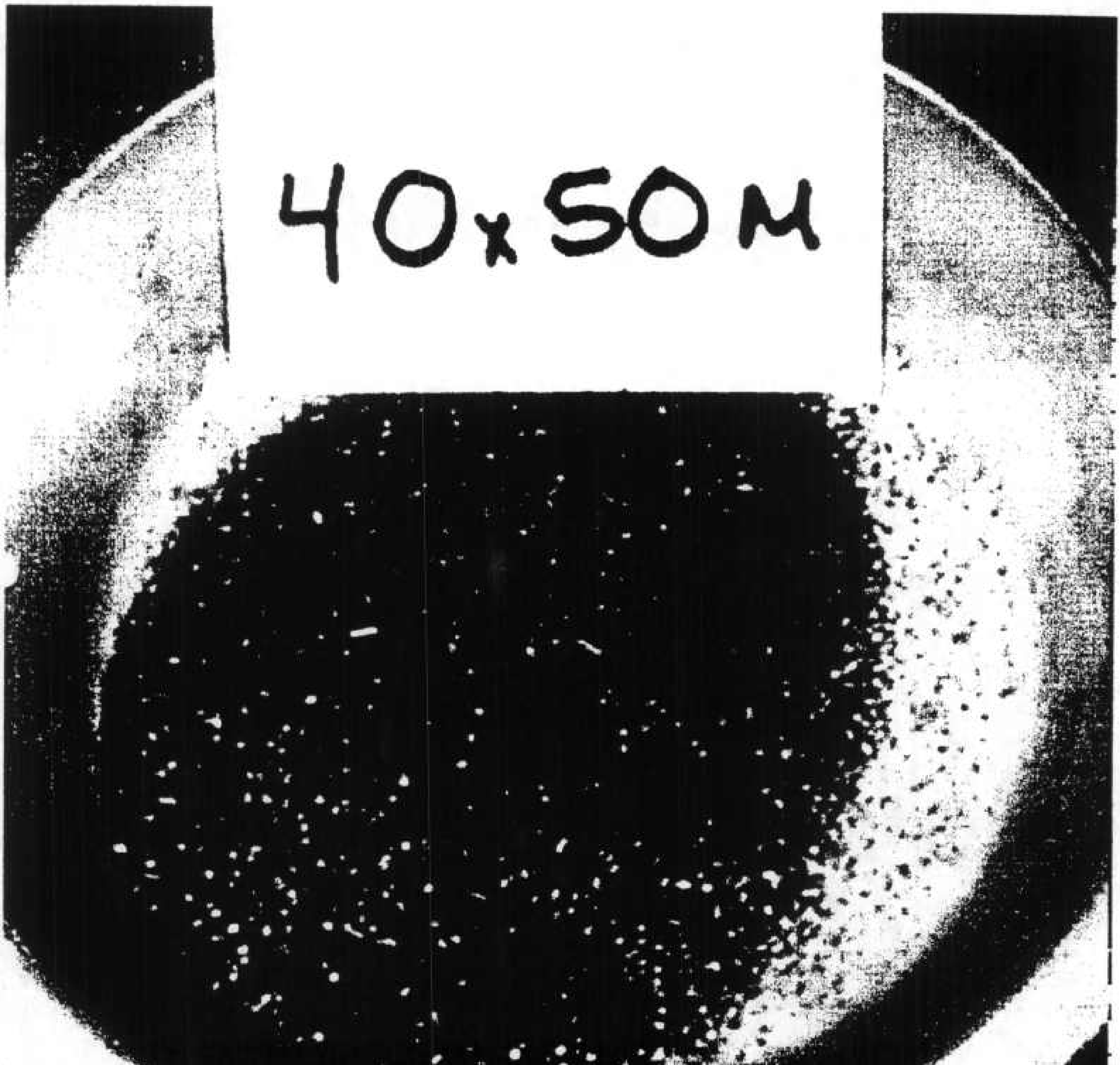
SEATTLE COMPOSITE

SEATTLE COMPOSITE

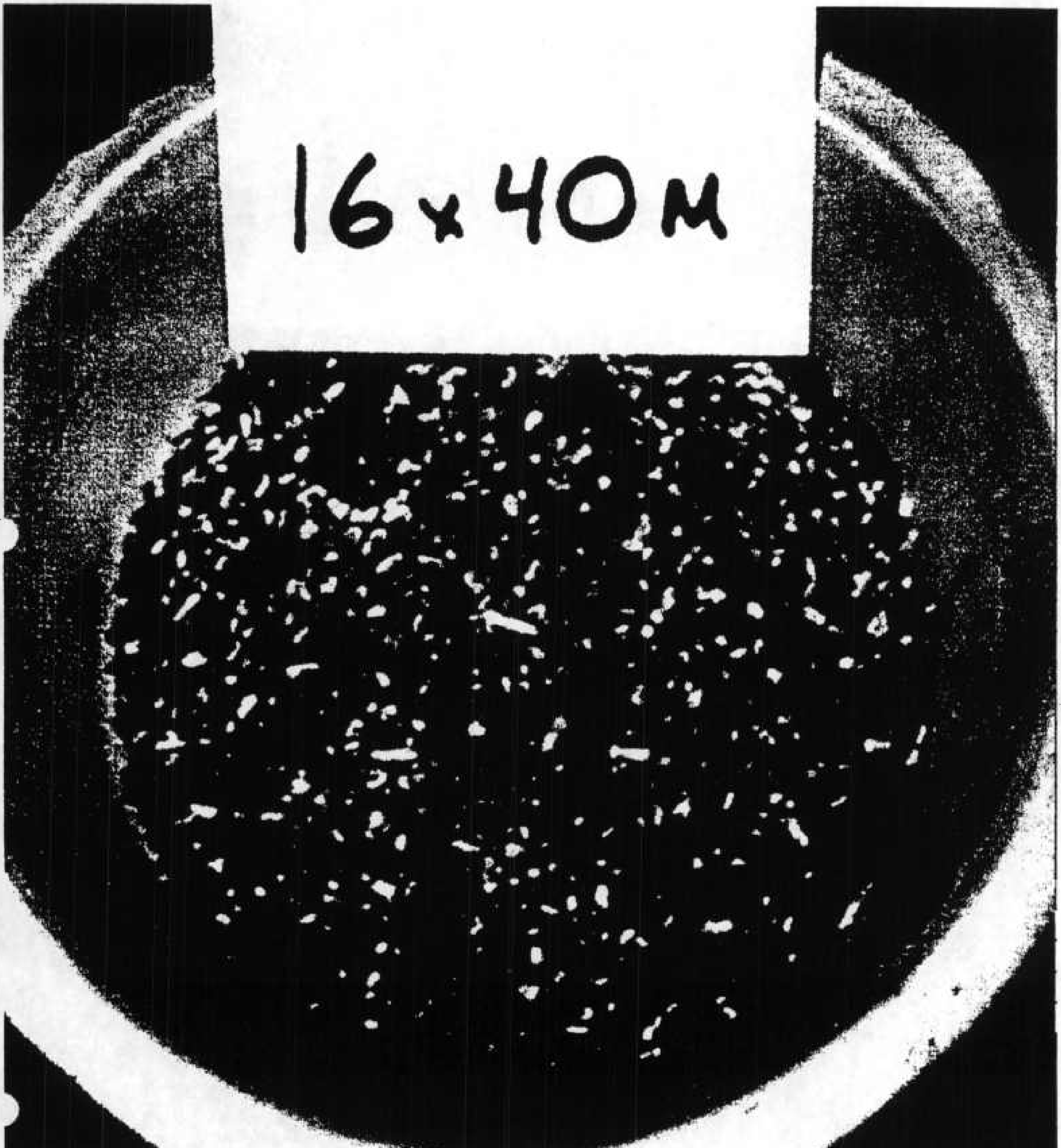
SEATTLE COMPOSITE



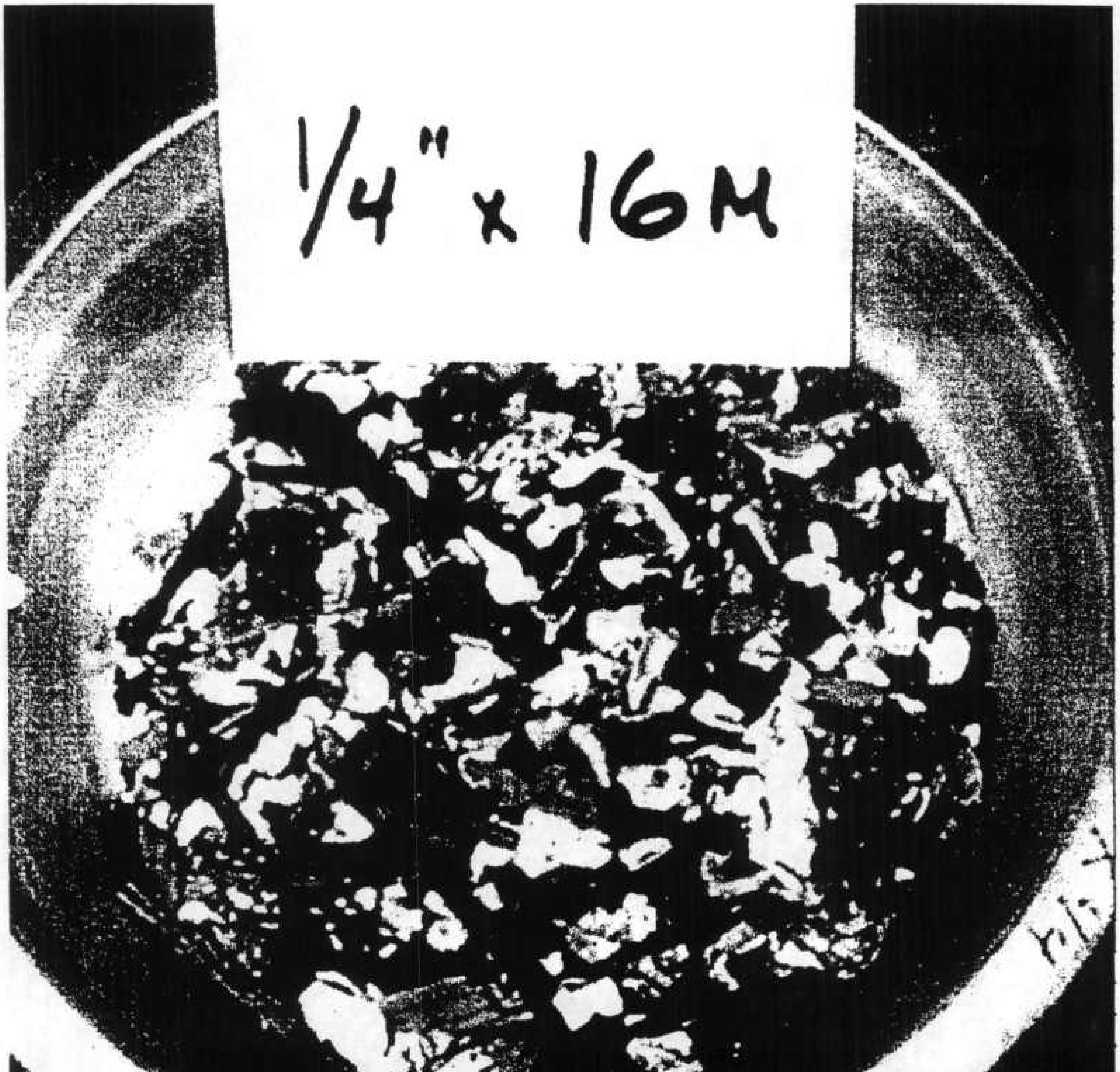
SEATTLE COMPOSITE



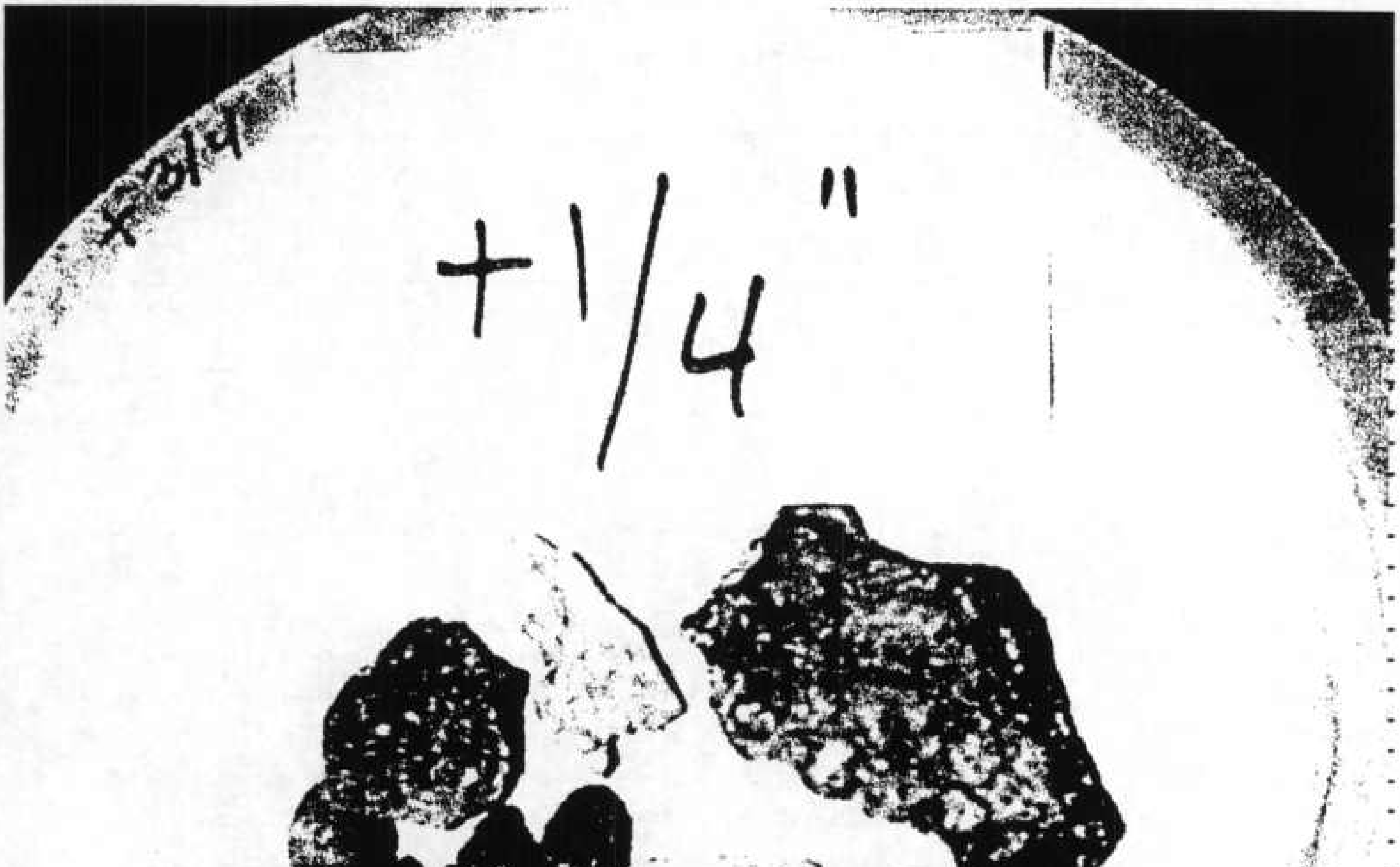
SEATTLE COMPOSITE



SEATTLE COMPOSITE



SEATTLE COMPOSITE



SHEALY ENVIRONMENTAL SERVICES, INC. Seattle

Scientists and Consultants

106 VANTAGE POINT DRIVE
CAYCE, SOUTH CAROLINA 29033

(803) 791-9700
FAX (803) 791-9111
www.shealyenvironmental.com

CERTIFICATE OF ANALYSIS

SC DHEC No. 32010 NC DEHNR No. 329

Client: Fuller Company
2040 Avenue C
Bethlehem, PA 18017

PO Number: 2519874108
Attention: Michael Prokesca

SHEALY Lab No: 182122R
Description: SAMPLE A

Date Received: 12/02/99
Date Reported: 12/09/99

CONFIDENTIAL

Coll. Date:
Coll. Time:

QA/QC Officer [signature]

V.P. Analytical MR

Parameters	Method	Result	Units	Reg. Limit	Date Prepared	Date Analysed	Anal.
INORGANICS							
% Solids	160.3	99.9	%			12/06/99 1730	JPB
TCLP METALS							
Arsenic	1311/6010B	<0.0050	mg/l	5.0	12/07/99 0830	12/07/99 2130	PTS
Barium	1311/6010B	0.029	mg/l	100.0	12/07/99 0830	12/07/99 2130	PTS
Cadmium	1311/6010B	<0.0020	mg/l	1.0	12/07/99 0830	12/07/99 2130	PTS
Chromium	1311/6010B	<0.0050	mg/l	5.0	12/07/99 0830	12/07/99 2130	PTS
Lead	1311/6010B	0.016	mg/l	5.0	12/07/99 0830	12/07/99 2130	PTS
Selenium	1311/6010B	<0.0050	mg/l	1.0	12/07/99 0830	12/07/99 2130	PTS
Silver	1311/6010B	<0.0050	mg/l	5.0	12/07/99 0830	12/07/99 2130	PTS
Mercury	1311/7470A	0.00066	mg/l	0.2	12/09/99 1030	12/09/99 1643	PTC

2

SVEDALA INDUSTRIES, INC.
WASTE COMBUSTION CAPABILITIES

	PROJECT/CUSTOMER	YEAR	WASTE TYPE	TYPE OF EQUIPMENT	HEAT RELEASE/ PRIMARY-SECONDARY	COMMENTS
1	WEST VIRGINIA PULP & PAPER	1965	CHEMICAL WASTES	ROTARY KILN 15 X 80	145 MMBTU/HR	EQUIPMENT SUPPLY
2	WEST VIRGINIA PULP AND PAPER	1966	CHEMICAL WASTES	ROTARY KILN 15 X 80	145 MMBTU/HR	EQUIPMENT SUPPLY
3	MONSANTO/ENVIRO-CHEM	1973	MUNICIPAL REFUSE	ROTARY KILN 20 x 100	250 MBTU/HR	EQUIPMENT SUPPLY
4	GENERAL ELECTRIC	1979	CHEMICAL WASTES	ROTARY KILN 12.5 X 35	45 MBTU/HR	DRUM WASTE FED INTO SYSTEM
5	ROY F. WESTON	1986	PCB SOILS	ROTARY KILN 7.5 X 25, SCC	35 MBTU/HR	TRANSPORTABLE SYSTEM/THREE SITES
6	INTERNATIONAL TECHNOLOGY	1986	CONTAMINATED SOILS	ROTARY KILN 7.5 X 45	50 MBTU/HR	TRANSPORTABLE SYSTEM/THREE SITES
7	DUPONT CORPORATION	1986	CONTAMINATED SOILS	ROTARY KILN 7.7 X 45	50 MBTU/HR	ON-SITE CLEANUP/TRANSPOR-TABLE SYSTEM
8	DEPT. OF ARMY	1987	CHEMICAL WASTES	CONFIDENTIAL	CONFIDENTIAL	CONFIDENTIAL
9	WASTE TECH SERVICES	1988	CHEMICAL WASTES	ROTARY KILN 10.5 X 30, SCC	50 MBTU/HR	FIXED PROCESS SITE
10	DEPT. OF ENERGY	1988	URANIUM RECOVERY	CONFIDENTIAL	CONFIDENTIAL	CONFIDENTIAL
11	McGILL ENVIRONMENTAL	1988	CHEMICAL WASTE	ROTARY KILN 9.5 X 30	50 MBTU/HR	TURNKEY TRANSPORTABLE SYSTEM
12	ENVIRITE FIELD SERVICES	1988	CONTAMINATED SOILS	ROTARY KILN 7.5 X 45	50 MBTU/HR	TRANSPORTABLE SYSTEM
13	McGILL ENVIRONMENTAL	1988	HAZARDOUS WASTE	ROTARY KILN 7.5 X 45	50 MBTU/HR	TRANSPORTABLE SYSTEM
14	GLAXO CO.	1989	BIOMEDICAL WASTE	FIXED HEARTH HR 75, SCC	8 MBTU/HR	BIOHAZARDOUS/RADIOACTIVE RESEARCH
15	DUPONT CORPORATION	1989	INDUSTRIAL WASTE	ROTARY KILN 12 X 50, SCC	60 MBTU/HR	TURNKEY SYSTEM/WASTE HEAT RECOVERY

SVEDALA INDUSTRIES, INC.
WASTE COMBUSTION CAPABILITIES

	PROJECT/CUSTOMER	YEAR	WASTE TYPE	TYPE OF EQUIPMENT	HEAT RELEASE/ PRIMARY-SECONDARY	COMMENTS
16	USPCI/STEARNS	1990	CONTAMINATED SOILS	ROTARY KILN 10 X 85	40 MBTU/HR	REGIONAL COMMERCIAL FACILITY
17	USPCI/STEARNS	1990	CHEMICAL WASTES	ROTARY KILN 16 X 50	100 MBTU/HR	REGIONAL COMMERCIAL FACILITY
18	IT McGILL	1990	CONTAMINATED SOIL	ROTARY KILN 13.5 X 75	145 MBTU/HR	TRANSPORTABLE SYSTEM
19	WASTE TECH SERVICES	1991	CHEMICAL WASTES	ROTARY KILN 11 X 40, SCC	75 MBTU/HR	PETRO-CHEMICAL FACILITY
20	MERCK & CO.	1991	BIOMEDICAL WASTES	ROTARY KILN 8 X 20, SCC	10 MBTU/HR	COMPLETE SYSTEM/MULTIPLE FEED SYSTEM
21	MERCK & CO.	1992	BIOMEDICAL WASTES	ROTARY KILN 10 X 35, SCC	30 MBTU/HR	COMPLETE SYSTEM/MULTIPLE FEED SYSTEM
22	IT-OHM	1992	HAZARDOUS WASTE	ROTARY KILN 13.5 X 75, SCC	145 MBTU/HR	EQUIPMENT SUPPLY
23	E. YOUNG CHEMICAL	1992	INDUSTRIAL WASTES	ROTARY KILN 12 X 50, SCC	60 MBTU/HR	PROCESS DESIGN AND EQUIPMENT SUPPLY
24	CHI MEI CORPORATION	1993	INDUSTRIAL WASTES	ROTARY KILN 12.5 X 55, SCC	70 MBTU/HR	COMPLETE SYSTEM
25	MITSUI/HIRAKAWA GUIDOM	1994	INDUSTRIAL WASTES	ROTARY KILN 5' X 15'	2.7 MBTU/HR	TEST KILN FOR JAPAN
26	ANDERSON 2000	1995	HAZARDOUS WASTES	ROTARY KILN 11.5' X 30'	25 MMBTU/HR	EQUIPMENT SUPPLY
27	DANISH WASTE MANAGEMENT	1995	HAZARDOUS WASTES	ROTARY KILN 11' X 40'	55 MBTU/HR	COMPLETE SYSTEM

3

TEST PROGRAM

for the

BENEFICIAL REUSE & CONVERSION OF RIVER CLAY INTO LIGHTWEIGHT AGGREGATE

Prepared by

HARBORROCK HOLDINGS LLC

Harbor Rock

Revision 000

March 2000

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1.0 INTRODUCTION

HarborRock Holdings LLC, a Delaware limited liability corporation, or affiliates (HarborRock), is currently considering the use of a lightweight aggregate system to process materials dredged from harbor locations in order to produce a marketable lightweight aggregate. The block diagram in Figure 1.1 illustrates the primary process phases included in a conventional lightweight aggregate process. The process selected to handle a feed containing materials mined or dredged from harbor or rivers includes an additional step to precondition the raw material prior to processing. This step is used to combust all carbon present in the mined river clay and to ensure control of the kiln off gas emissions (see Figure 1.2). The removal of the carbon enables the dredged material to be processed in the rotary kiln without the addition of expandable clays or shales commonly used to produce a high quality aggregate. The diagram in Figure 1.3 provides a more detailed diagram of the process flow and equipment.

HarborRock has developed this Test Program to evaluate the lightweight aggregate concept depicted in Figures 1.2 and 1.3 using a representative mined river clay feedstock material. It is a generic test program that gets tailored to meet the needs for the particular project being evaluated. HarborRock prefers to use river clays obtained from various locations if possible. The rationale for this decision is based on the fact that the blended dredge material would generally have higher concentrations of organic compounds and metals than found in any one specific harbor. Therefore, data obtained from using this sample should represent a worst-case scenario for material sources from other locations. Data on emission levels etc. from this test will be mathematically corrected or correlated to materials found in other harbors as appropriate to obtain representative estimates of emission profiles for those locations.

The Test Program is designed to evaluate the lightweight aggregate process, to obtain data for developing mass and energy balances, and to determine air emissions. Results of the test program will be used to set process and operating guarantees for the full-scale system. The results of the program will ultimately be used to confirm if the aggregate is a marketable product. This test program specifies tests and procedures for the feed materials, raw pellet mixes, muffle furnace tests, drying operation, calcining operation, kiln operation and air emissions measurements.

Proprietary and Confidential

Figure 1.1

CONVENTIONAL LIGHTWEIGHT AGGREGATE FACILITY

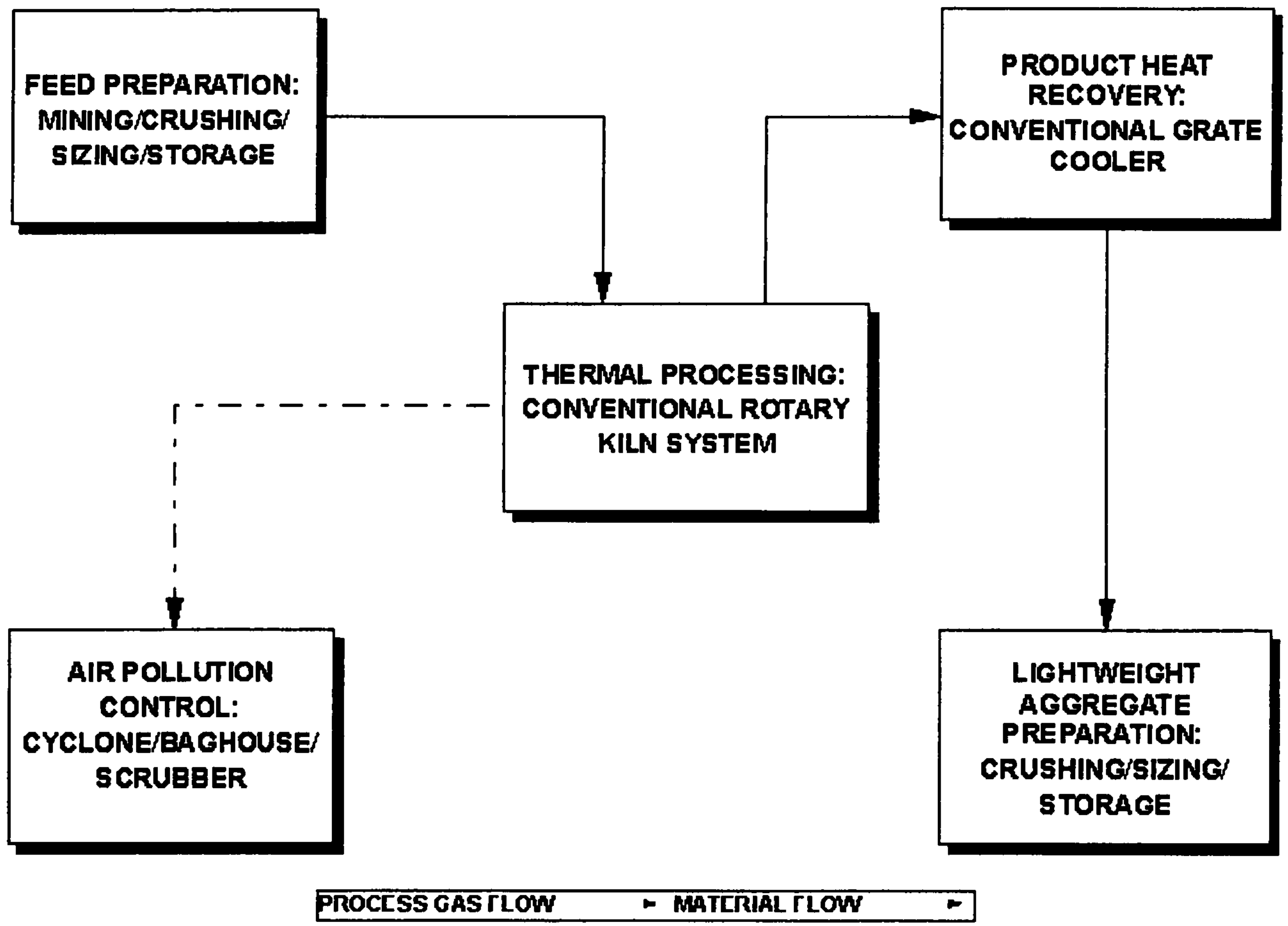
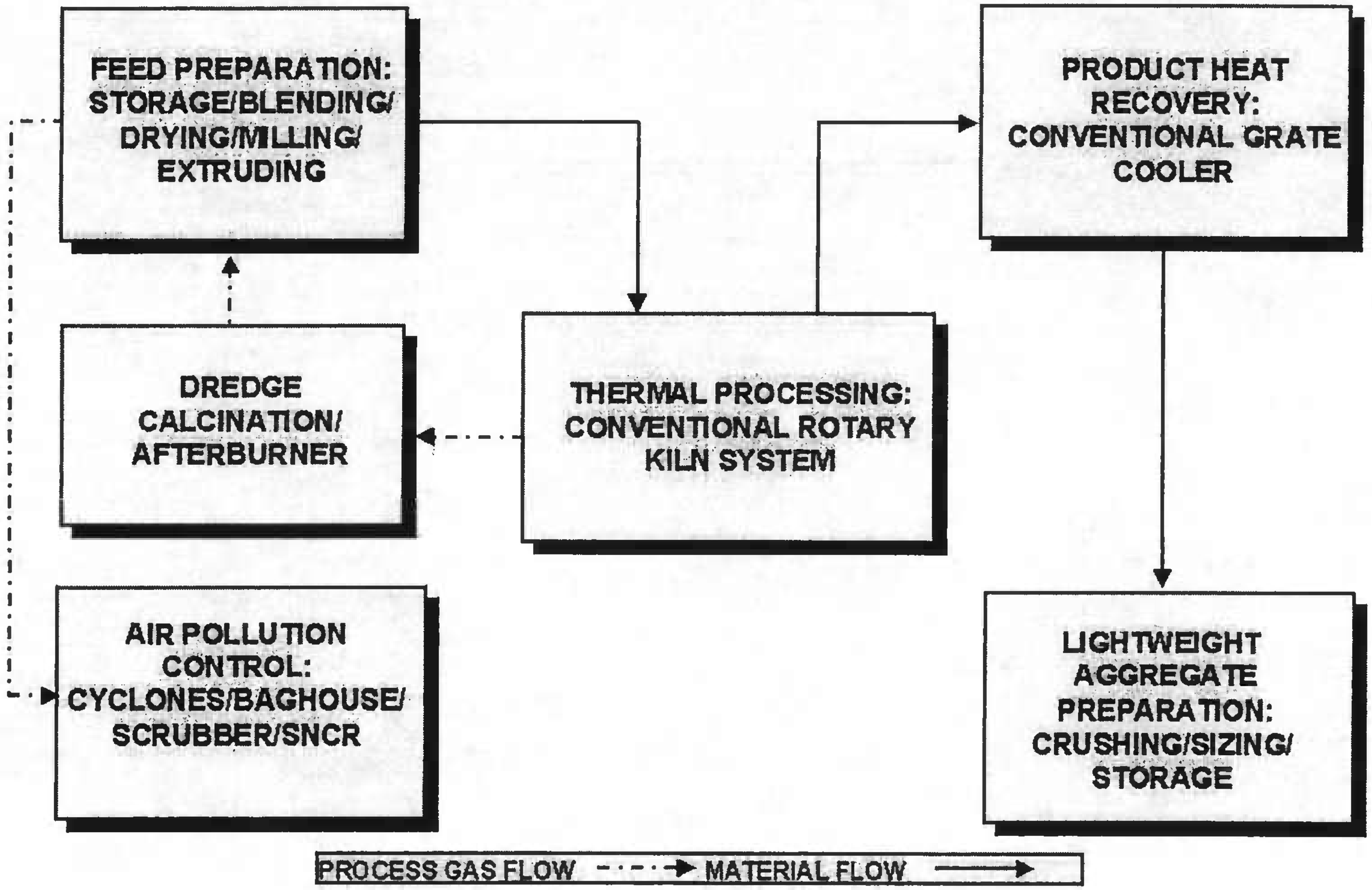


Figure 1.2

HARBORLIGHT LIGHTWEIGHT AGGREGATE FACILITY



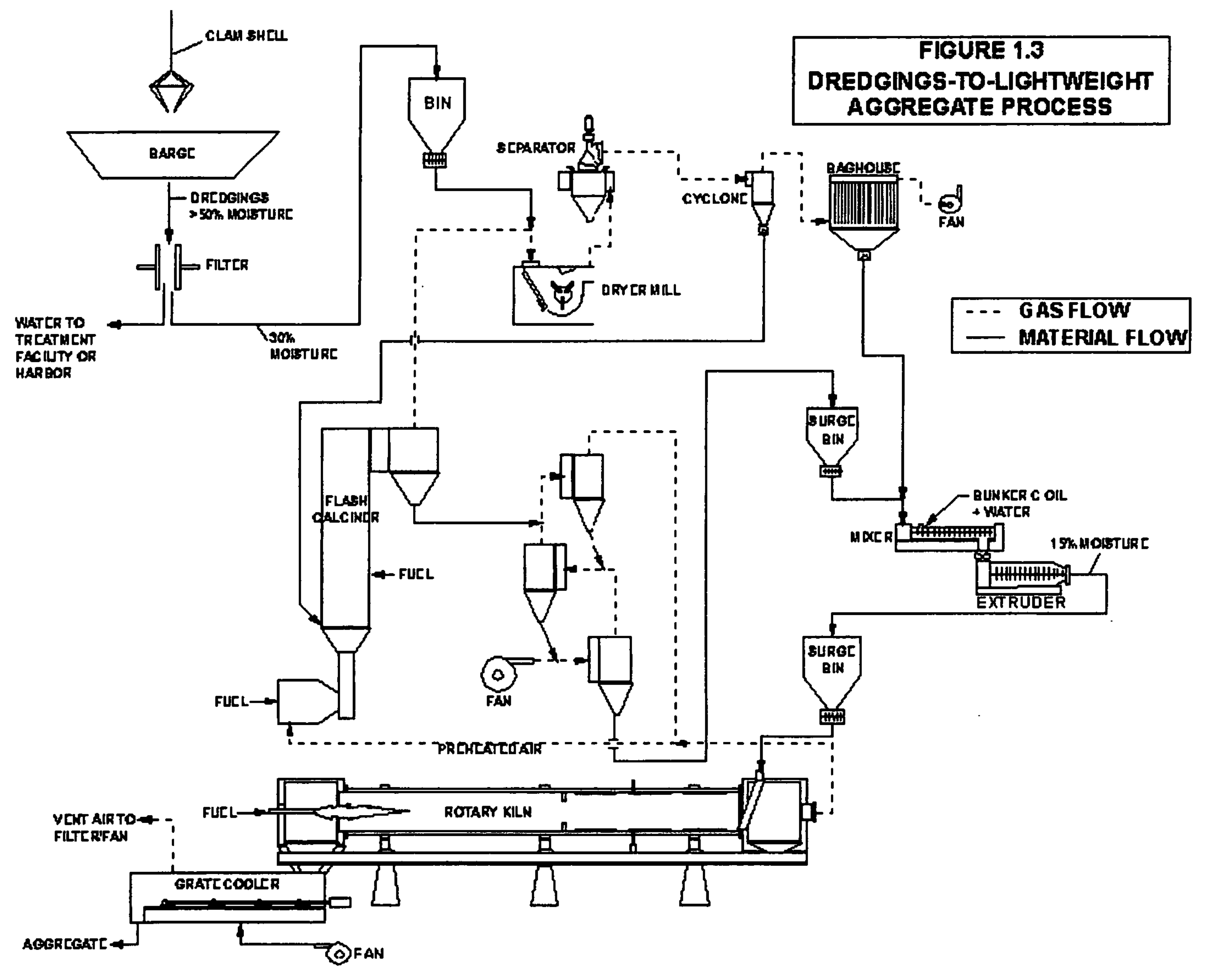


FIGURE 1.3
DREDGINGS-TO-LIGHTWEIGHT AGGREGATE PROCESS

FIGURE 3.1
SUMMARY OF STEPS AND RESPONSIBILITIES

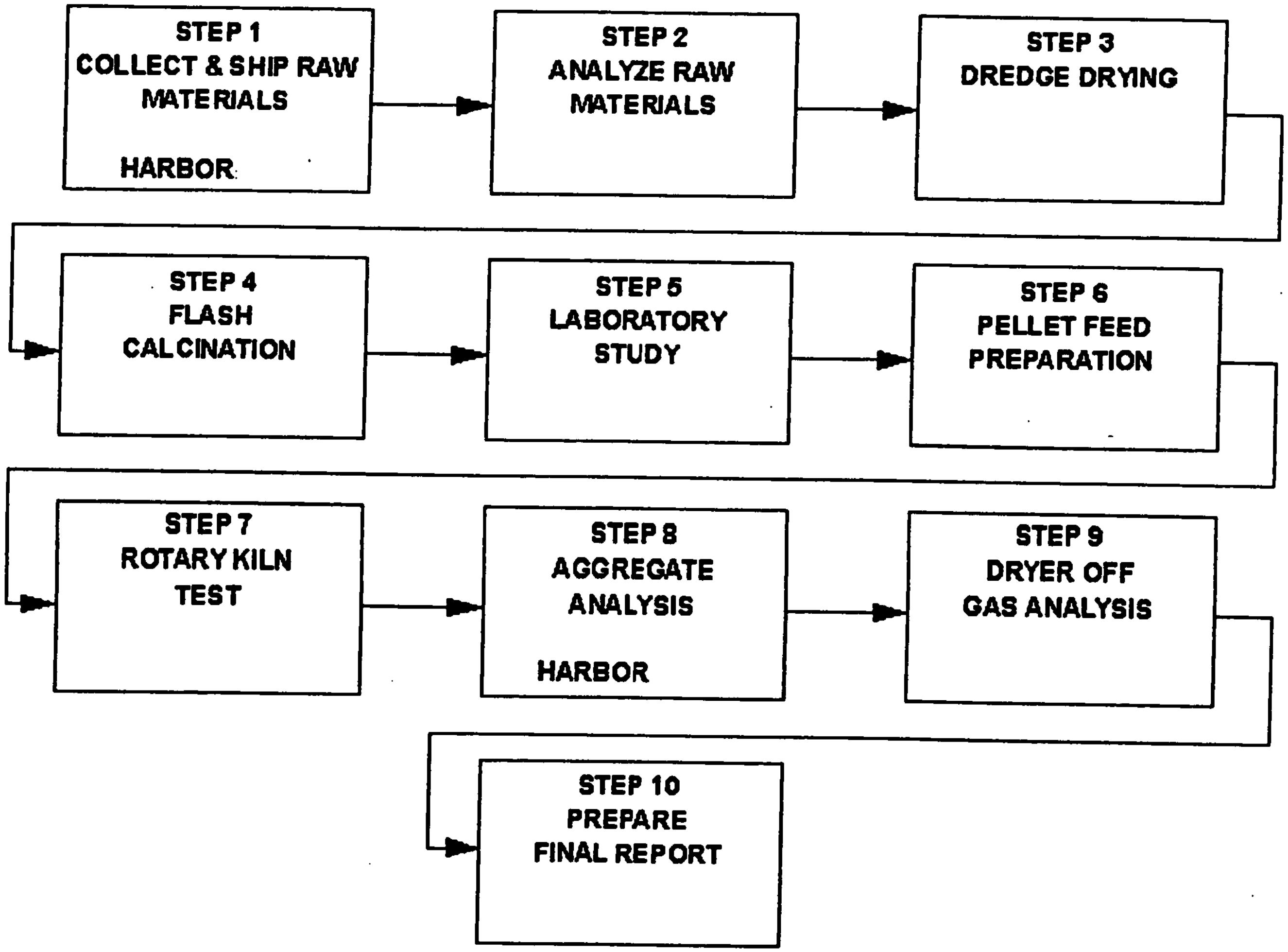
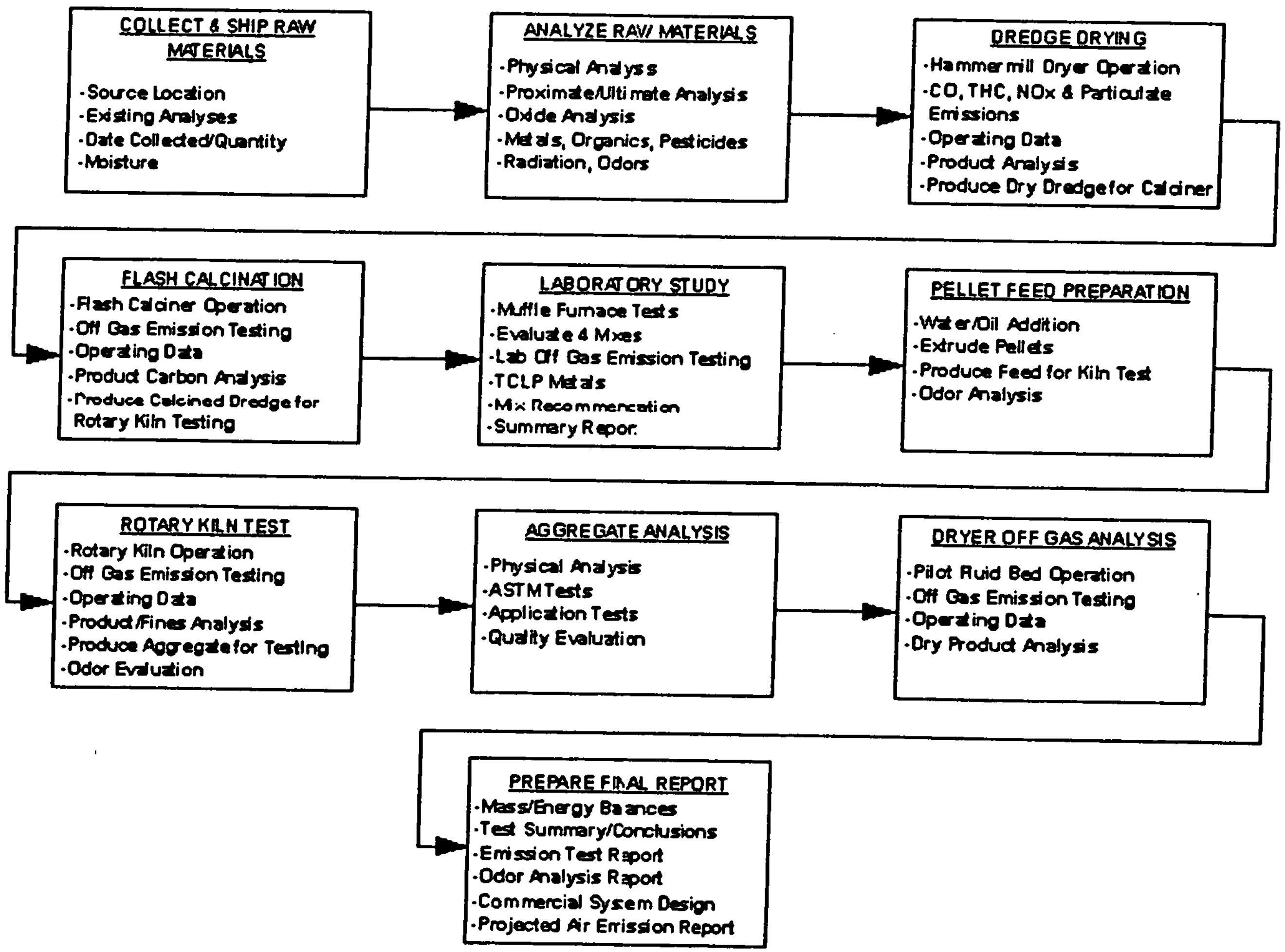


FIGURE 3.2
PROCESS TEST FLOW DIAGRAM



2.0 OBJECTIVES

General objectives of this test and development program are as follows:

- To demonstrate at the pilot scale that harbor river clays can be converted to a marketable, lightweight aggregate product.
- To provide test data upon which to base the engineering design for a commercial-scale lightweight aggregate production facility.
- To serve as a key component of an R&D program being undertaken by HarborRock to support permit applications for the commercial lightweight aggregate process.

The specific technical objectives of this test and development program are as follows:

- To demonstrate the adequacy of the equipment planned for drying, calcining, extruding and rotary kiln operations.
- To produce a sufficient quantity of lightweight aggregate to facilitate standard aggregate tests in order to determine the quality of the lightweight aggregate produced.
- To quantify air emissions for the design of required air pollution control (APC) systems to satisfy regulatory requirements.
- To determine production and energy consumption rates for the full-scale plant.
- To collect sufficient data for the process vendor to offer HarborRock process guarantees for the full-scale kiln system.

3.0 DESCRIPTION OF TEST PROGRAM

This section describes the procedures and responsibilities for running this Test Program. The entities responsible for carrying out these procedures include HarborRock, and Process Vendor, herein after referred to as Vendor. Both entities have distinct responsibilities, which have been integrated to produce a smooth running test program. Vendor will direct the program once a final plan is agreed upon by both parties and shall prepare the final report.

The program procedures have been divided into ten steps, with the responsibility for each step assigned to the appropriate entities. The flowchart depicted in Figure 3.1 summarizes the steps and identifies responsibilities for each. The flow sheet depicted in Figure 3.2 provides a schematic of the test program and lists the parameters, which will be documented. A schedule for completing each step is presented in Figure 3.3. Detailed descriptions of each step are presented below.

3.1 Step 1 - Collect and Ship Raw Materials

HarborRock is responsible for coordinating the collection, packaging, labeling, and shipment of the raw materials to Vendor. Vendor, in tum, is responsible for receiving the materials upon delivery.

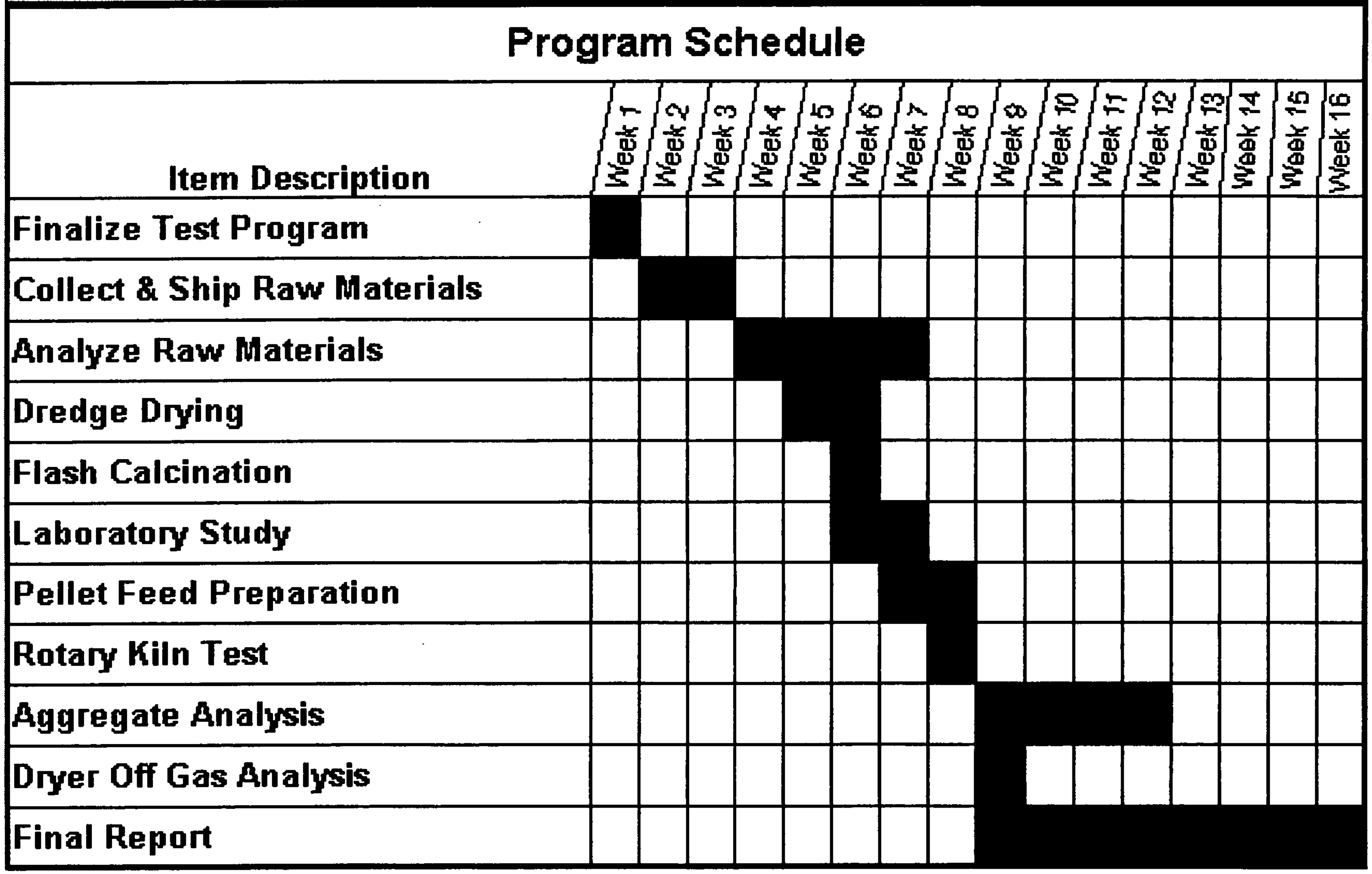
Material Collection

Ten cubic yards of dredge material will be collected by HarborRock and shipped to Vendor to facilitate the analysis described in Sections 3.2 –3.9. The dredge material must be prepared/beneficiated in accordance with procedures and specifications agreed upon based on the results obtained from the analysis outlined in Section 3.2. Preliminary test work indicates that the material should be beneficiated to 100 mesh. See Section 4.0 for instructions pertaining to the collection and shipment of the samples. The materials must be representative (e.g., in appearance, texture, physical properties, and chemical properties) of the materials that will be used for the full-scale plant. A copy of the shipping manifest to be used is included in Section 4. For each material collected, the following will be recorded:

- Name of harbor and locations in harbor where the harbor dredgings were collected.
- Date(s) all materials were collected.
- Pre-existing analytical data for the harbor dredgings.
- Moisture levels of samples to be delivered to Vendor.

The above information will be provided to Vendor in the form of shipping manifests for each drum of material. The manifest will indicate if the materials provided are representative of materials that will be used for the full-scale plant. The manifest will be provided to the Vendor prior to receipt of the materials and will be addressed accordingly.

Figure 3.3


Program Schedule
Item Description
Week 1
Week 2
Week 3
Week 4
Week 5
Week 6
Week 7
Week 8
Week 9
Week 10
Week 11
Week 12
Week 13
Week 14
Week 15
Week 16
Finalize Test Program
Collect & Ship Raw Materials
Analyze Raw Materials
Dredge Drying
Flash Calcination
Laboratory Study
Pellet Feed Preparation
Rotary Kiln Test
Aggregate Analysis
Dryer Off Gas Analysis
Final Report

Packaging and Labeling:

Harbor dredged material will be shipped in covered containers utilizing disposable plastic drum liners. The containers will be clean and dry prior to receiving materials and will be labeled to identify the originator of the material and contents (e.g. "Dredgings"), dredging location, date material was collected, and the purpose of the material ("For Dredging to LWA Test Program"). Details of the filling and sampling procedures are discussed in Section 4.

Shipment:

The materials will be shipped to Vendor within one (1) day of being collected and containerized, and will be delivered within two (2) calendar days of shipment. Vendor will receive the materials as per the time frame depicted in Figure 3.3 so that the materials can be processed as soon after receipt as possible. HarborRock will confirm the exact delivery date with Vendor one week prior to the shipment of the materials. The materials will be shipped to the following Vendor address:

3.2 Step 2 - Analyze Raw Materials

HarborRock is responsible for collecting and coordinating the shipping of small samples of harbor dredgings collected from one or more locations. Vendor is to be responsible receiving the raw materials, and representative sampling and analysis as outlined in Section 4 and Table 4.1. The Vendor laboratory for subcontractor analysis will coordinate proper sample volumes, containers, sampling techniques, and shipment.

The "as received" harbor dredge material (10 gallon sample) will be wet sieved in order to determine the complete particle size distribution, and then the following fractions will be produced: +1/4", ¼" x 16 mesh, 16 x 50 mesh, 50 x 100 mesh and –100 mesh. If more than one dredge sample is provided, the analysis will be performed on a blend of the samples. These fractions will be analyzed to determine their complete oxide composition, and this data then used in conjunction with the Vendor's compositional diagram analysis to determine if and where a separation should be made to remove bulk aggregates and sand to optimize the chemical composition of the dredge material for lightweight aggregate production. The conclusion drawn by Vendor will be reviewed with HarborRock, and HarborRock is then responsible for selecting the point of particle separation

A representative composite sample of the harbor dredgings (after beneficiation if required) and sand/aggregates removed from harbor dredgings will be prepared by Vendor and tested for some or all of the parameters listed below:

- Proximate Analysis (moisture, fixed carbon, volatile matter, ash content)
- Ultimate Analysis (hydrogen, oxygen, nitrogen, sulfur, chlorine, fluorine)
- Oxide Analysis including Loss on Ignition, Alkalis, Total Sulfur and CO_2
- Physical Analysis including Bulk Density and Particle Sizing
- Analysis for Metals, VOC's, semi-VOC's, Dioxin/furans, PCB's, Pesticides, Asbestos, Total Reduced Sulfur, and Ammonia
- TCLP including selected Metals, Organics and Pesticides
- Gamma Radiation levels
- Odor evaluation.

A complete listing of sampling parameters and methods is detailed in Section 4, and listed in Table 4.1.

3.3 Step 3 – Dredge Drying

It is assumed that the bulk dredge sample provided by HarborRock will have been beneficiated to remove aggregates and sand as per Vendor's recommendation (see Section 3.2). If dredge material from more than one location is provided, the materials will be combined in their proper proportions prior to drying. The dredge will be dried using an air-swept hammermill dryer system similar in design to the proposed commercial mill system. See Figure 3.4 for a schematic of the pilot hammermill dryer circuit including instrumentation and sampling locations. The hammermill inlet gas temperature will be controlled at 1280°F, and the feed rate to the mill will be adjusted to obtain a mill outlet gas temperature of 200°F. The mill outlet gas temperature may then be adjusted as required to control the product moisture level (<5%), and/or minimize the emission of carbon monoxide and hydrocarbons. The gas flow through the mill will be adjusted to support a feed capacity of 1-2 tph. If material particle size reduction is required, the mill dynamic classifier will be adjusted as required to obtain the recommended material top size.

The drying operation will include recording of the hammermill operating data including capacity, gas flow rate, temperature profile, pressure profile, product moisture, product particle size distribution and emissions (oxygen, carbon monoxide, nitrous oxides, total particulate and total hydrocarbons only). This information will be documented by Vendor and included in the final test report. The mill will be operated for a period of 3-6 hours to demonstrate drying effectiveness.

3.4 Step 4 – Flash Calcination

A portion of the dried dredge produced in Step 3 (1000-1500 pounds) will be flash calcined in a suspension flash calcination system to evaluate carbon burnout and calciner emissions. See Figure 3.5 for a schematic of the pilot calciner system. The calciner will be operated with a temperature profile, process gas velocity and oxygen concentration representative of expected commercial calciner operating conditions. The feed rate to the calciner will be in the range of 25-75 lb/hr. Bunker C oil will be added to the calciner feed at a rate of 0.5-1% to simulate the VOC's that will be introduced into the calciner from the rotary kiln circuit. Calciner discharge samples will be periodically collected and checked for total carbon content and, if necessary, calciner-operating conditions will be adjusted to improve carbon bumout and/or reduce calciner carbon monoxide emissions. All calciner products will be collected in the system baghouse. A sufficient quantity of representative calcined dredge will be produced to facilitate the laboratory study (Step 5) and rotary kiln testing (Step 7).

A composite sample of representative calciner product will be analyzed as specified in Table 4.1. Vendor may arrange for an emission-testing firm to be present to analyze the calciner off gas stream at the baghouse outlet location as specified in Table 4.2 for "Calciner Off Gas". Calciner operating data including feed rate, production rate, fuel input and air input will be recorded. This information will be documented by Vendor and included in the final test report.

3.5 Step 5 – Laboratory Study

One pellet mix containing calcined dredge and bunker C oil will be made up for the pilot rotary kiln test (Step 7). The bunker C oil is added to supply the volatile component required for material bloating (expansion) during thermal processing. The composition of this mix will be determined by the Vendor and HarborRock based upon furnace tests on pellet mixes prepared by Vendor containing varying amounts of bunker C oil (0-1%). All mix designs will be reported on a **dry basis**, and the dredge chemistry utilized for the mix design study will be based on a blend of the dredge samples (following particle separation) supplied by HarborRock if multiple dredge samples are provided.

Vendor is responsible for conducting standard lab scale muffle furnace tests on one mix and issuing a preliminary summary report to HarborRock. The purpose of the furnace tests are to evaluate temperature requirements and determine the amount of bunker C oil that is required to yield a lightweight aggregate product of the desired characteristics. Furnace tests will be performed utilizing ½" diameter extruded pellets produced from the calcined dredge produced in Step 4.

FIGURE 3.4
PILOT HAMMERMILL DRYER CIRCUIT

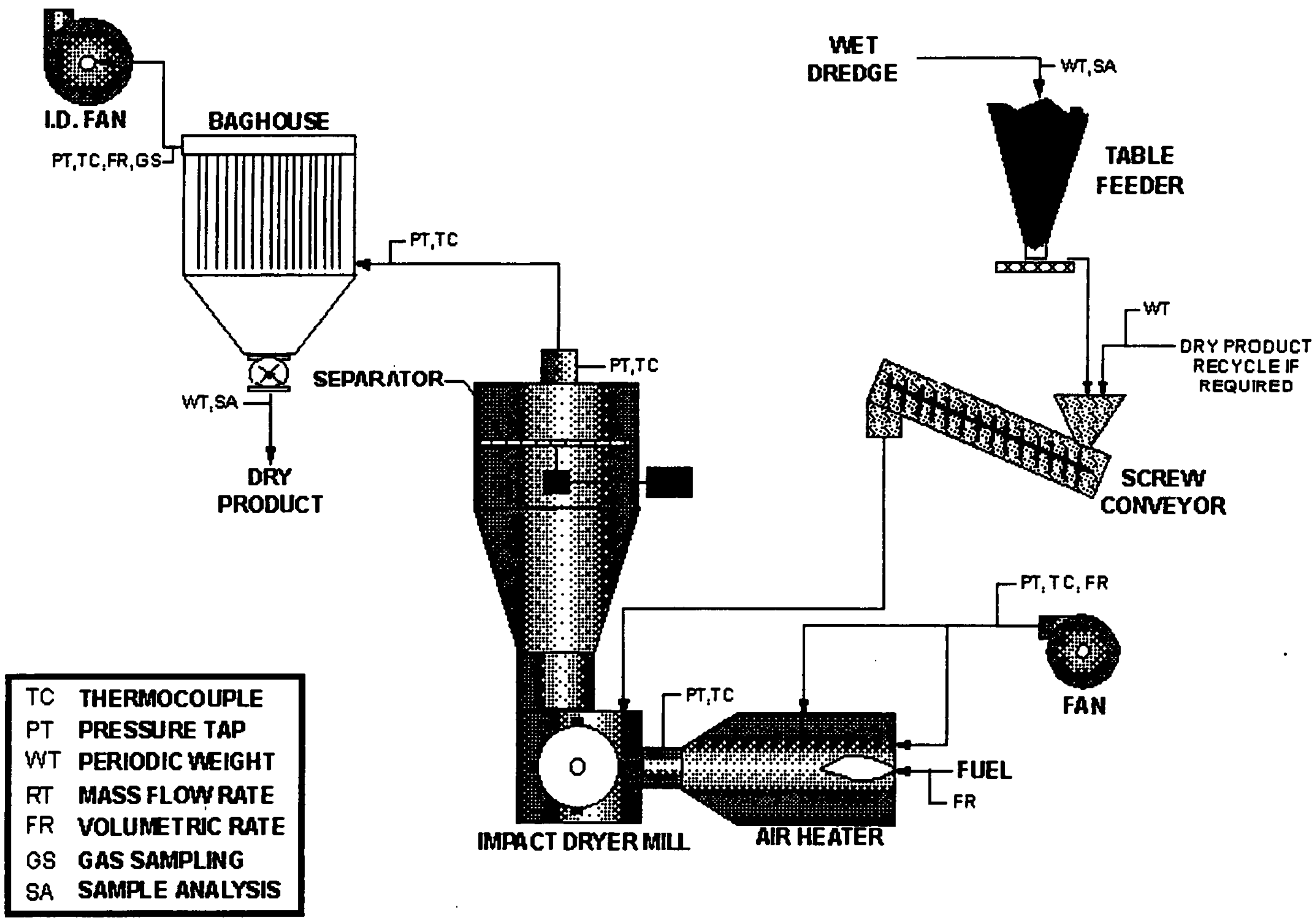
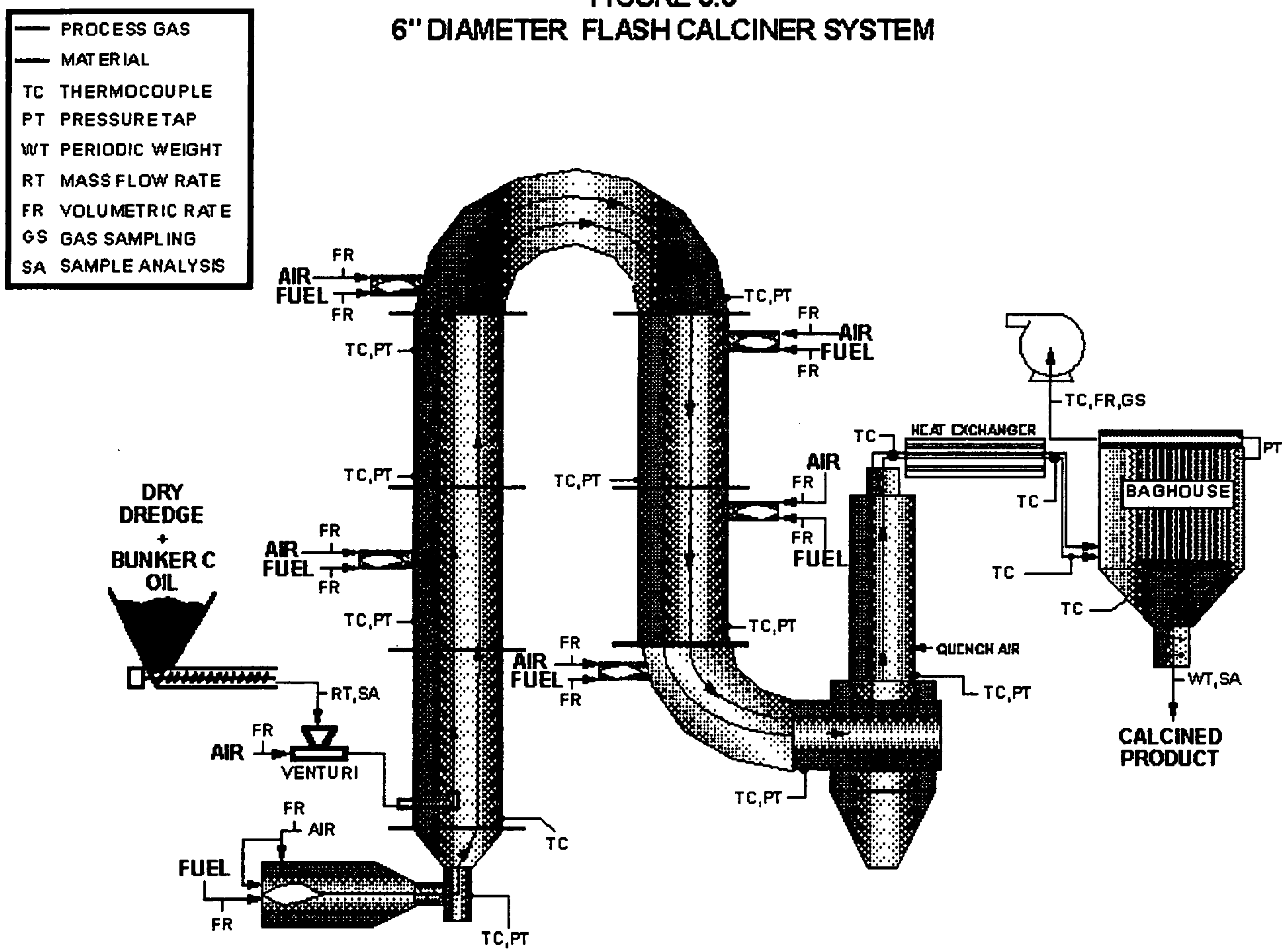


FIGURE 3.5
6" DIAMETER FLASH CALCINER SYSTEM



Standard muffle fumace trial tests will be conducted to simulate the commercial single rotary kiln approach to producing LWA. The thermal steps included in the standard lab scale LWA test include the following:

- Drying: 232°C for 3 minutes
- Preheat: raise to 315°C in 6 minutes and hold for 7 minutes
- Firing: raise to 1107°C in 17 minutes and hold for 10 minutes

Before beginning each trial test, the pellet mix composition, moisture and bulk density will be documented, and the emission of odors will be noted during the course of the test. Following the completion of each test, the sample weight loss, volumetric change, bulk density and crushing strength will be measured. The firing temperature may be increased/decreased depending on the properties of the product produced in an attempt to satisfy target bulk density and strength levels. In addition, the thermal profile utilized may be adjusted as deemed necessary to best simulate expected commercial rotary kiln process conditions. The tests are performed in an atmosphere containing 21% O_2 and 79% N_2.

Two lab scale emission evaluations may be conducted on the one mix to determine the emission of SO_2, CO, THC, CH_4, CO and NO_x as a function of temperature. The lab furnace will be purged with gas containing 10% O_2, 10% CO_2 and 80% N_2. Fired products from the two emission tests will be analyzed to determine TCLP metals levels.

Vendor will provide a preliminary summary of the lightweight aggregate burn and emission test results, including a discussion of areas of concern and mix design recommendations. Based on the results of the muffle furnace tests, one mix will be selected for the pilot rotary kiln test as agreed upon by HarborRock and Vendor.

3.6 Step 6 – Pellet Feed Preparation

Once the final mix design for the rotary kiln test has been jointly agreed upon by HarborRock and Vendor, Vendor is responsible for producing a pellet feed. The product produced in the calciner circuit will be combined with bunker C oil and water in a mortar mixer. Water will be added to obtain a free moisture level required to optimize extruding (approximately 15%). The material will then be extruded to produce ½" diameter x 1" pellets using the pilot extruder. The wet extrusions will be immediately placed in 55-gallon drums with clean plastic liners and sealed to prevent drying. Each container will be labeled to identify the contents; date material was processed, net weight, project number, and lab number. Composite samples of the wet extrusions will be analyzed to determine free moisture content. A minimum of 1200 pounds of wet extrusions will be produced to support the rotary kiln operation.

3.7 Step 7 – Rotary Kiln Test

Vendor is responsible for (1) conducting kiln testing in the pilot rotary kiln using pellets produced in Step 6 and (2) arranging for analytical testing and emissions testing as described in this section and summarized in Tables 4.1 and 4.2. Miscellaneous samples will be analyzed as required to facilitate mass balances and evaluate acid gas formation including sulfur, chlorine and fluorine balances. The results of all tests will be included in the final test report.

A high temperature rotary kiln and afterburner will be used. The afterburner is utilized in the pilot circuit for the purpose of controlling off gas emissions. An afterburner may not be required in the commercial process because the flash calciner circuit provides emission control. See Figure 3.6 for a schematic of the pilot kiln system. Trial runs will be conducted at a bloating temperature between 1050°C and 1150°C (1922 F to 2102 F). Vendor will determine actual temperatures upon evaluation of the furnace test results (Step 5). For each trial run, parameters listed below will be recorded under steady state conditions every 30-60 minutes, and this data will be included in the final test report.

- Inlet Pellet Composition
- Feed Pellet Rate and Kiln Loading
- Temperature Profile along the Length of the Kiln
- Kiln Burner Air and Fuel Input Rates
- Kiln Exit Gas Flow and Composition
- Filter Inlet Temperature
- Filter Inlet Gas Flow & Composition
- Production Rate
- Dust Loss Rate

All data collected during the trial test, copies of Vendor's daily logs, and small samples of product produced will be submitted to HarborRock upon completion of the tests.

3.8 **Step 8 – Aggregate Analysis**

HarborRock is responsible for selecting product samples to be sized for application testing, providing specifications to Vendor, and submitting samples of the product to potential aggregate users. Vendor is responsible for crushing/sizing the aggregate product as required to satisfy aggregate size specifications. The following tests will be performed to evaluate the aggregate samples produced in the pilot system:

- Environmental tests to determine compliance with "lean fill" requirements including TPHC, B/N-15, pesticides/PCBs, VO+15, metals, cyanide.
- Gradation (ASTM C136)
- Unit Weight (ASTM C29)
- Organic Impurities (ASTM C40)
- Staining & Iron Content (ASTM C641)
- Clay Lumps & Friables (ASTM C142)
- Loss On Ignition (ASTM C114)
- Drying Shrinkage (ASTM C157)
- Pop Outs (ASTM C151)
- Freezing & Thawing (ASTM C67)
- Concrete Masonry Block Tests including:
    1. Compressive Strength (ASTM C140)
    2. Absorption & Moisture Content (ASTM C140)
    3. Unit Weight (ASTM C140)
    4. Shrinkage (ASTM C426)
    5. Efflorescence (ASTM C67)
    6. Fire Rating (U.L. Method)

Approximately 50 pounds of aggregate are required for these tests. The results of the aggregate tests will be included in a final report provided by the testing firm, and this report will be included in Vendor's final report.

3.9 Step 9 – Dryer Off Gas Analysis

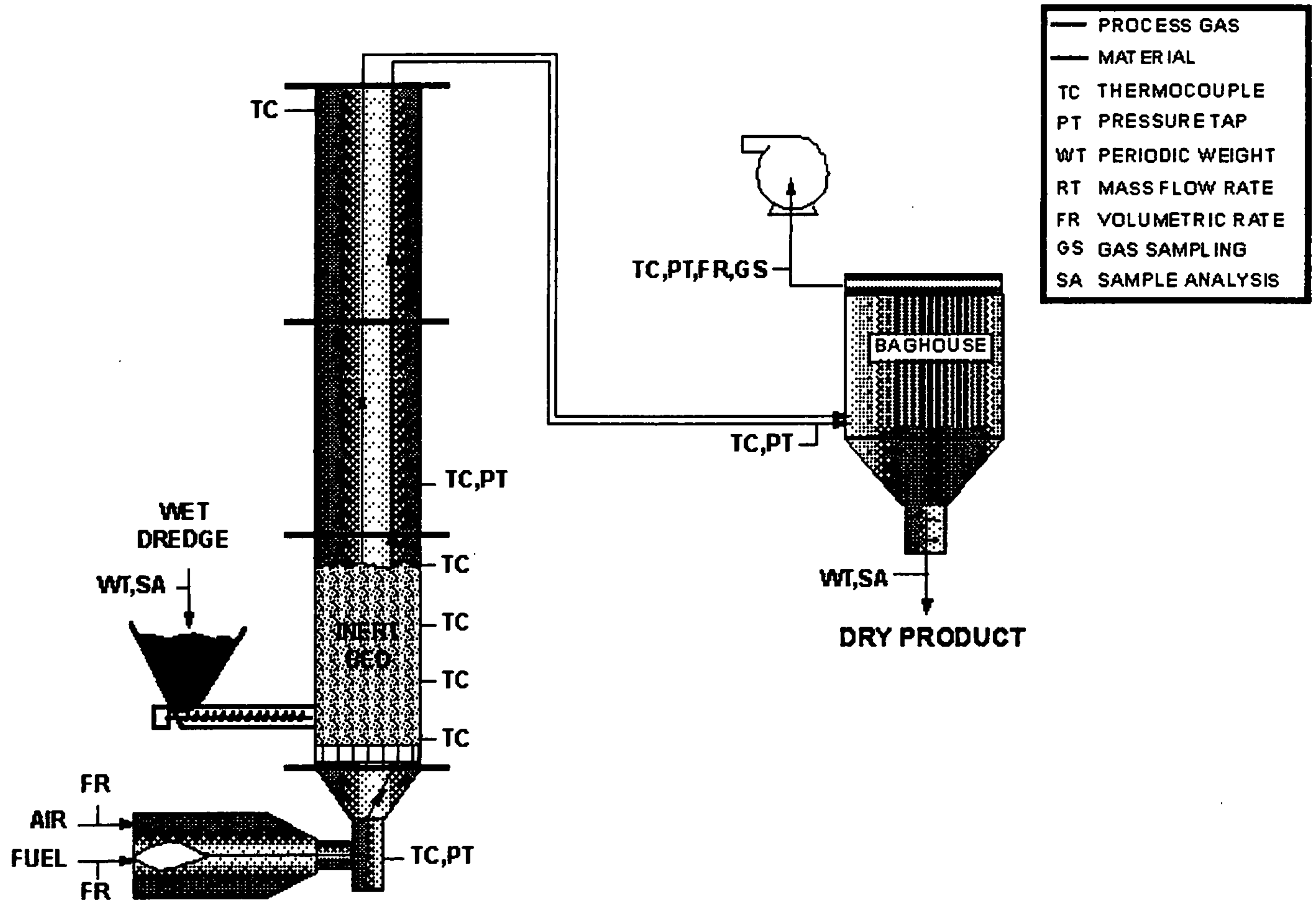
Vendor may arrange for an emission-testing firm to be present to analyze the dryer off gas stream as specified in Table 4.2 for "Dryer Exhaust". As the off gas analysis will require approximately 12 hours to complete, a separate small scale test may be performed to reduce the amount of dredge material required for the program. The feed composition for this test is the same as the material used for the kiln feed, and will be composed of wet beneficiated dredge. This material will be fed into a fluid bed operating with an inert bed of ceramic pellets. (See Figure 3.7 for a schematic of the fluid bed system). The inlet temperature to the bed will be controlled at 1280°F, and the feed rate to the unit adjusted to obtain a gas/material outlet temperature corresponding to the outlet gas temperature utilized in Step 3. This operation will simulate the thermal conditions used in the hammermill dryer. Off gas testing will be conducted using this bench scale unit. The CO, NO_x, total particulate and total hydrocarbon concentrations will be compared to those measured from the short period of operation in the pilot hammermill dryer to ensure that the data from the bench scale fluid bed unit is representative.

3.10 Step 10 - Prepare Final Report

Vendor is responsible for preparing a Final Test Report for submittal to HarborRock. The report will include all test data collected, emission report from the subcontractor, pilot system mass and energy balances, a preliminary commercial system process flow diagram, projected mass and energy balances for the commercial system, and conclusions based on the pilot rotary kiln study. Projected uncontrolled emission levels for the full-scale facility will be the responsibility of Vendor Company. The project design-engineering firm or emission consultant will have the responsibility of projecting controlled emission levels.

Completion of the draft report is scheduled for XX-XX 20009. Review comments from HarborRock are due by XX-XX 2000. Issue of the Final Report is scheduled for XX-XX 2000.

FIGURE 3.7
6" DIAMETER FLUID BED SYSTEM



4.1 Test Material Sampling Protocol

This protocol defines the steps to be employed while sampling the test materials at their respective collection points. The following total quantity of wet beneficiated harbor dredgings will be collected:

10 cubic yards of Harbor Dredging @ 50% H_2O

The test materials will be collected and shipped in 55-gallon drums or lined super sacks. If drums are used, these drums must be clean, dry, and free from flaking rust internally, have no intemal sharp edges and be in good condition. Before filling with material, the drum should be lined with removable plastic liner.

During filling, a sample (approximately ½ quart) will be taken from the mid-point in the container. These samples should be composited in 5-gallon container lined with a Teflon bag. The Teflon lining in the sample container should be sealed between the depositing of each sample. When these samples are received by Vendor, samples for SVOC's, pesticides, PCB's, dioxin/furans and metals will be transferred to two 16 oz. glass jars with Teflon lined lids. Samples for VOC's will be transferred to two 40 ml glass vials with Teflon lined lids. Containers should be filled completed with no air space remaining.

During collection of the samples, weather conditions and/or any unusual conditions that may affect the representativeness of the samples should be noted on the test material manifest. Unusual conditions may include the following:

- Unusual appearance of the sample,
- Samples taken from bottom of excavation,
- Exposure to rain.

When filling of each individual drum has been completed, the plastic lining should be sealed and the lid of the drum attached. Each drum, including the composite sample, should be labeled showing the following information:

- Material
- Date and time of filling
- Source material address
- Destination

The test material should then be shipped to Vendor with a copy of the completed test material manifest attached to each drum. The sample container should also have a manifest attached to the sealed container. The manifest should clearly state that this is a composite sample for testing at Vendor.

4.2 Air Emission Tests

Vendor is responsible for overseeing tests on the off gases from the drying, calcining and rotary kiln systems if required by the appropriate permitting agency. As outlined in Table 4.2, a subcontractor will be required to measure a number of emitted components. Prior to the start of the program, HarborRock and Vendor will select a qualified subcontractor to perform the gas sampling tests. The work outlined for the subcontractor will be performed in two complete sets at each location during steady state operation. The emission testing to be performed by Vendor (NO_x, SO_2, CO, CO_2, O_2, H_2O, THC, CH_4) will be conducted on a continuous basis. Table 4.2 lists the air pollutants for which testing will be performed, as well as methods that will be used to conduct the tests. With regards to metals, VOC's and SVOC's, the specific elements and compounds to be tested are the same as those to be evaluated in the feedstock solids. A specific listing is provided in Section 4.3.

All data collected by Vendor will be included and discussed in the final report. The data collected by the subcontractor will be summarized in a separate report, and this report will be appended to Vendor's final report. Projected controlled emission levels for the full-scale facility will be the responsibility of the project design engineering firm or emission consultant.

4.3 Elements Included Under Analytical Methods for Solids

Table 4.1 details the analyses required on specific solids as outlined in the Vendor test proposal, and provides an EPA method for testing. The following methods mentioned analyze the following:

Oxides:

- SiO_2 - Silica
- Al_2O_3 - Alumina
- Fe_2O_3 - Iron
- CaO - Calcium
- P_2O_5 - Phosphorus
- TiO_2 - Titanium
- Mn_2O_3 - Manganese

Metals:

- Ag - Silver
- As - Arsenic
- Ba - Barium
- Be - Beryllium
- Cd - Cadmium
- Cr - Chromium
- Cu - Copper
- Hg - Mercury

Mn - Manganese
Mo - Molybdenum
Ni - Nickel
P - Phosphorous
Pb - Lead
Sb - Antimony
Se - Selenium
Ti - Titanium
Tl - Thallium
Zn - Zinc

Solid Sample Analyses Continued:

Semi-Volatile Organics:

Acenaphthalene
1,4-Dichlorobenzene
2,4-Dinitrotoluene
Naphthalene
Phenol
Pyrene
1,2,4-Trichlorobenzene
Benzo(a)Pyrene
Dinitrocresol

Volatile Organics:

Acetone
Benzene
Ethyl benzene
Methylene chloride
1,1,1-Trichloroethane
Xylenes
Acrylonitrile
Carbon tetrachloride
Chloroform
Vinyl chloride
Chlorobenzene

Pesticides/PCB's:

Aldrin
Chlordane
PCB's

Solid Sample Analyses Continued:

TCLP Metals:

Ag - Silver
As - Arsenic
Ba - Barium
Be - Beryllium
Cd - Cadmium
Cr - Chromium
Cu - Copper
Hg - Mercury
Mn - Manganese
Mo - Molybdenum
Ni - Nickel
Pb - Lead
Sb - Antimony
Se - Selenium
Tl - Thallium
Zn - Zinc

TCLP Organics/Pesticides:

Acenaphthalene
1,4-Dichlorobenzene
2,4-Dinitrotoluene
Naphthalene
Phenol
Pyrene
1,2,4-Trichlorobenzene
Benzo(a)Pyrene
Dinitrocresol
Acetone
Benzene
Ethyl benzene
Methylene chloride

1,1,1-Trichloroethane
Xylenes
Acrylonitrile
Carbon tetrachloride

Solid Sample Analyses Continued:

TCLP Organics/Pesticides (cont.):
Chloroform
Vinyl chloride
Chlorobenzene
Aldrin
Chlordane
PCB's

Dioxins/Furans:
2378-TCDD
12378-PeCDD
123478-HxCDD
123678-HxCDD
123789-HxCDD
1234678-HpCDD
OCDD
Total TCDD
Total PeCDD
Total HxCDD
Total HpCDD
2378-TCDF
12378-PeCDF
23478-PeCDF
123478-HxCDF
123678-HxCDF
234678-HxCDF
123789-HxCDF
OCDF
Total TCDF
Total PeCDF
Total HxCDF
Total HpCDF

HARBORROCK

TEST MATERIAL MANIFEST

Manifest Date:______________	Date Sample Taken:______________
Ship to:______________	Received By:______________
______________	Sign:______________
______________	Print:______________
______________	Date:______________
______________	Phone:______________

Description of Test Material:	______________		
	______________		
Location of Sample:	______________		
Elevation Sample Taken:	______________		
Estimated Sample Weight:	______________		
Container Description:	______________		
Weather Conditions:	(Clear)	(P.Cloudy)	(Cloudy)
Rainfall:	________	Inches (estimate)	
Temperature:	________	°F (estimate)	
Other Data:	______________		
	______________		

SECURE A MANIFEST COPY TO EACH CONTAINER THAT IS SHIPPED.

5.0 CONCLUSIONS

This process test and development program has been prepared by HarborRock and Vendor to evaluate the feasibility of processing river clays in a rotary kiln process to produce a marketable lightweight aggregate. The program consists of ten steps with the responsibility of these steps assigned to HarborRock and/or Vendor. Vendor's responsibilities include evaluating the results of the program and for producing a final report discussing the overall feasibility of the process excluding environmental impact assessments. This final report will be submitted to HarborRock for a determination of commercial feasibility.

Table 4.1									
Analytical Methods For Solids									
Test	**Method**	**Agent**	**Dredge Composite**	**Sand/ Aggregate**	**Calciner Product**	**Furnace Pellets**	**Fired Pellets**	**Filter Fines**	**Fluid Bed Product**
			Beneficiated	Composite	Fines				
			1 sample	1 sample	1 each	4 samples	1 sample	1 sample	1 sample
Proximate Analysis									
Moisture	ASTM D3302	Vendor	X	X	X		X	X	X
Fixed Carbon	ASTM D3172	Vendor	X	X	X		X	X	X
Volatile matter	ASTM D3172	Vendor	X	X	X		X	X	X
Ash Content	ASTM D3172	Vendor	X	X	X		X	X	X
Ultimate Analysis									
Elemental carbon	ASTM D3176	Vendor	X	X	X		X	X	X
Hydrogen	ASTM D3176	Vendor	X	X	X		X	X	X
Oxygen	ASTM D3176	Vendor	X	X	X		X	X	X
Sulphur	ASTM D3176	Vendor	X	X	X		X	X	X
Nitrogen	ASTM D3176	Vendor	X	X	X		X	X	X
Chlorine	ASTM D2361	Vendor	X	X	X		X	X	X
Fluorine		Vendor	X	X	X		X	X	X
Specific Energy			X	X				X	X
Oxide Analysis									
Oxides	ASTM C114	Vendor	X	X	X	X	X	X	X
Alkalis	ASTM C114	Vendor	X	X	X	X	X	X	X
Total Sulphur	ASTM C114	Vendor	X	X	X	X	X	X	X
CO2	ASTM C25	Vendor	X	X	X			X	X
LOI @ 900 C	ASTM C114	Vendor	X	X	X	X	X	X	X
Metal Analysis	6010B		X	X	X		X	X	X
TCLP-Metals	1311/6010	Vendor	X	X	X	X	X	X	X
TCLP- Organics/pesticides	1311/8260B/8270C	Vendor	X	X	X		X	X	X
TCLP- Organics/pesticides	8082/8151/6010	Vendor							
Mercury	7471	Vendor	X	X	X		X	X	X
VOCs	8260B	Vendor	X	X	X		X	X	X
SVOC's	8270C	Vendor	X	X	X		X	X	X
Dioxins/Furans	8280	Vendor	X	X	X		X	X	X
Pesticides/PCB's	8082	Vendor	X	X	X		X	X	X
Total reduced Sulfur	6010B	Vendor	X	X	X		X	X	X
Asbestos	TEM-BULK	Vendor	X	X	X		X	X	X
Ammonia	350.1	Vendor	X	X	X			X	X
Odor Evaluation	EPA 140.1	Vendor	X	X	X				X
Radiation		Vendor	X	X	X				
Physical Analysis									
Bulk Density		Vendor	X	X	X	X	X	X	X
Sizing		Vendor	X	X	X	X	X	X	X
Aggregate Sizing	ASTM C330	Vendor				X	X		
Strength testing	ASTM C330	Vendor				X	X		
Water Absorption	ASTM C128	Vendor					X		

Table 4.2

Analytical Methods For Off-Gases

Test	**Method**	**Agent**	**Furnace**	**Hammermill**	**Fluid Bed**	**Calciner**	**Kiln**	**Kiln Filter**
			Tests	**Off Gas**	**Off Gas**	**Off Gas**	**Off Gas**	**Off Gas**
						4 samples	1 sample	1 sample
Flow rate	EPA RM 1- 4	Vendor		X	X	X	X	X
Temperaturre	EPA RM 1- 4	Vendor		X	X	X	X	X
Pressure	EPA RM 1- 4	Vendor		X	X	X	X	X
Moisture Content	EPA RM 4	Vendor		X	X	X	X	X
Oxygen Content	EPA RM 3A	Vendor	X	X	X	X	X	X
Total particulate matter	EPA RM 5	Vendor		X	X			
PM-10 Emissions	EPA RM 201A	Vendor			X			
SO2	EPA RM 6C	Vendor	X		X	X	X	X
HCL	EPA RM 26	Vendor			X	X	X	X
NOX	EPA RM 7E	Vendor	X	X	X	X	X	X
CO2	EPA RM 3A	Vendor	X		X	X	X	X
CO	EPA RM 10A	Vendor	X	X	X	X	X	X
Total Hydrocarbons	EPA RM 25A	Vendor	X	X	X	X	X	X
Trace Metals	EPA RM 29	Vendor			X	X	X	X
mercury	EPA RM 29	Vendor			X	X	X	X
Dioxins/Furans	EPA RM 23	Vendor			X	X	X	X
PCB's	EPA RM 23	Vendor			X	X	X	X
VOC's	EPA SW846,M30	Vendor			X	X	X	X
SVOC's	EPA SW846,M10	Vendor			X	X	X	X
Total reduced Sulfur	EPA RM 16B	Vendor			X	X	X	X
HF	EPA RM 13A	Vendor			X	X	X	X
H2SO4	EPA METHOD 8	Vendor			X	X	X	X
Ammonia		Vendor			X	X	X	X
Odor Level		Vendor		X	X	X		X

4

HarborRock

Beneficial Reuse & Conversion of River Clay into Lightweight Aggregate (LWA)

Contents

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Summary

- HarborRock Holdings, a Delaware LLC, formed to develop and manage projects that recycle and convert river clay into lightweight aggregate ("LWA").

- New application of proven, patented and proprietary technology with process guarantees.

- Immediate project opportunities in multiple national and international ports.
    - Wilmington, DE, New Jersey, San Francisco, & Seattle

- Environmentally sound projects endorsed by regulators, industry and environmental community.
    - Beneficial reuse of recyclable resource.
    - Provides a predictable, economic disposal option for the shipping industry.
    - Eliminates long term environmental issues related to alternative disposal options.
    - The HarborRock process safely and effectively destroys any organic compounds and meets newly issued (Oct. 1999) EPA emission standards.
    - HarborRock will not accept any hazardous materials.

- Quality of LWA produced is equal to or better than current competition.

The Best Disposal Option
Manufactured Lightweight Aggregate

- Harbor or river sediments are primarily composed of clay and silt, ideal materials for the manufacture of lightweight aggregate.

- Provides the ACOE, Ports and Industry with a viable solution
  - HarborRock recycling process is a perpetual and permanent disposal solution.
  - Eliminates need for future reauthorization, development and permitting.
  - Highly predictable.
  - Able to process large volumes of material.
  - Is not seasonally dependent.
  - Able to safely decontaminate sediments.
  - Eliminates potential long term health risks associated with "placement" alternatives for material not suitable for ocean disposal.

- Produces a practical, commercial end use product, creates economic development - jobs, tax base.

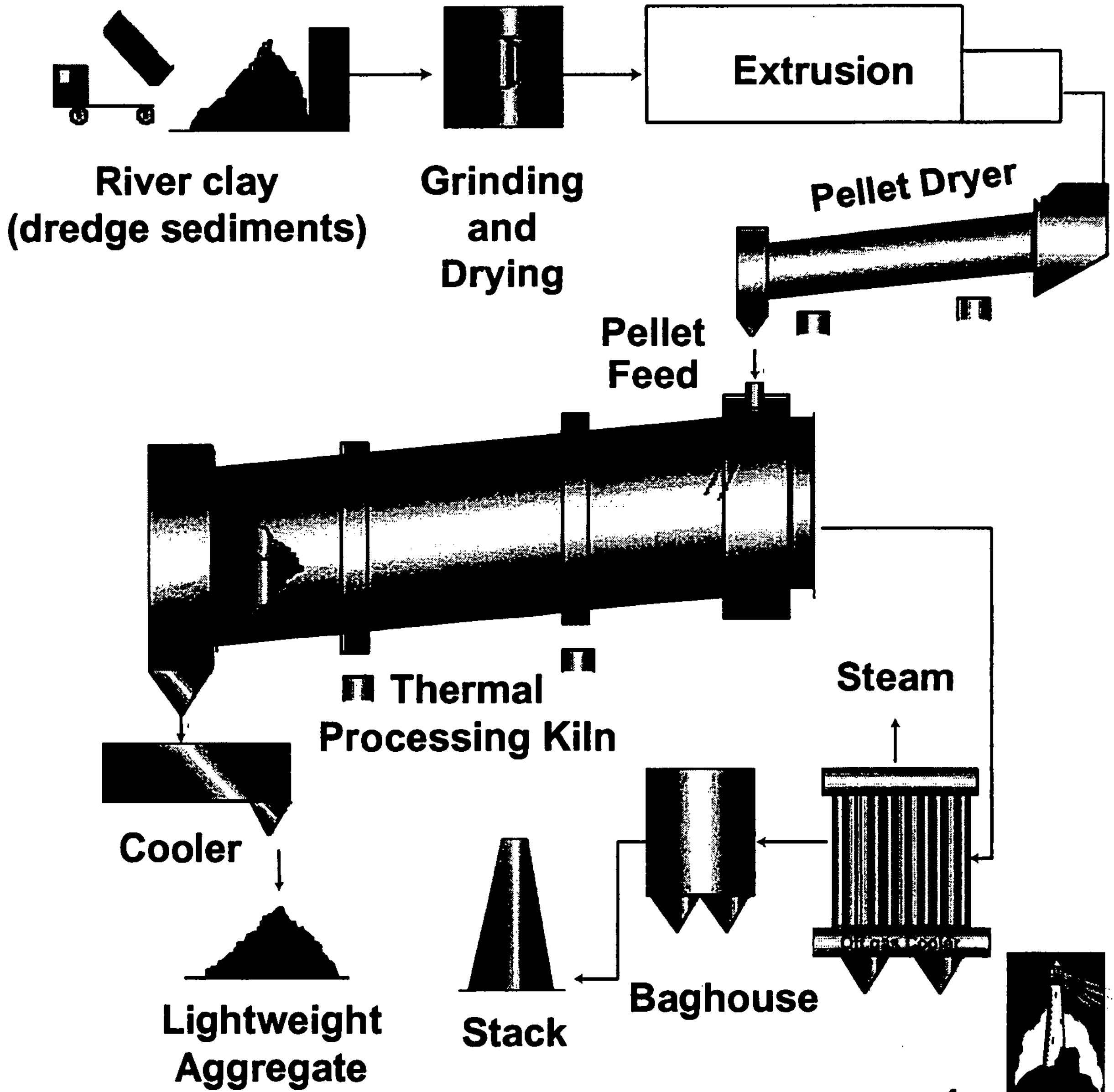
- The most cost-effective beneficial recycling decontamination option in most locations and is cost competitive with wetlands restoration/creation projects.

National Lightweight Aggregate Market

- National market for LWA is approximately 17 million tons per year.
- Only 10 million tons/year of LWA is currently produced or imported.
- Unreliable sourcing and supply of LWA from current producers.
  - 30 operating LWA plants in U.S. with 42 operating kilns.
  - Majority of the facilities independently owned
  - Located in rural areas next to quarries with high transport cost to market
  - 100% of existing production capacity is operating.
  - The average facility is more than 25 years old.
  - The majority of the facilities operating today:
    - not energy efficient
    - low reliability, high maintenance down time
    - lack advanced operator control systems
    - do not have current air pollution control equipment.
      - New EPA MACT (maximum achievable control technology) standards issued to reduce air emissions from both new and existing LWA kilns.
      - MACT standards will require significant outlays and lead to plant closure.

HarborRock General Process Description

River clay (mined sediments), are received on a tip floor via a loader or conveyor. The clay material is screened, dried, ground, and extruded into pellets. The green pellets are dried, then fed into a rotary kiln and fired. The lightweight aggregate is then cooled, graded and shipped to the end users.



HarborRock Holdings LLC Management Team

- Committed professionals currently employed in executive positions in government or industry involved in dredge material management, lightweight aggregate manufacture and sales, dense aggregates, finance and project development.

- Management team is a specialized, dedicated, highly respected group of individuals able to realize and maximize the financial returns of HarborRock Holdings LLC.

- Skill sets possessed by the HarborRock team include:
  - Engineering and environmental. Experience in industrial project development, construction and operations.
  - Legal. Experience in environmental and contractual issues, brownfield development and international dense aggregates.
  - Governmental and regulatory affairs. Experience in federal, state and local dredge material management policies and issues.
  - Executive. Officers with experience in operating LWA firm, including international sales and marketing.
  - Industrial project finance. Energy and environmental engineering project experience.

Potential U.S. HarborRock Locations Evaluated to Date

- Baltimore
- Boston
- Houston
- New York/New Jersey Harbor*
- Philadelphia*
- Portland
- San Francisco*
- Seattle/Tacoma*
- Wilmington, DE*

*LWA samples produced and evaluated from materials obtained from these locations.

Lightweight Aggregate - LWA

- LWA is a high-strength, low weight substitute for dense aggregate in building material applications. 1998 national sales were 10 million tons.

- LWA is used in:
  - light weight concrete blocks, ready-mix or structural concrete, specialty concrete products, geotechnical fill, horticulture, and road and bridge paving.

- Advantages over dense aggregate include:
  - higher R-value, better fire rating, less dead load, higher skid resistance, lower sound transmission, up to 40% less weight while maintaining adequate strength.

- Historically been manufactured by firing clay, shale or slate in a kiln that has a tendency to expand when heated, thus creating a lower density aggregate.

Current National LWA Market

- **Sales:**
  - Total Lightweight Aggregate Sales (1998) — 10 million tons/year

  - Sales growth rate (% increase)

• 1994 to 1995	7.8%
• 1995 to 1996	3.5%
• 1996 to 1997	4.4%
• 1997 to 1998	5.7%
• 4 yr. average annualized growth	5.3%

  - Sales by Market Sector/Application

• Masonry block	57.5%
• Ready Mix concrete (structural)	14.5%
• Pre-cast concrete products:	3.3%
• Asphalt	7.4%
• Geotechnical applications	3.9%
• Other	13.4%

National Dense Aggregate Market

- According to USGS figures, the use and production of crushed stone aggregate continues to rise, with corresponding price increases.

Year	Crushed stone Production (millions of tons)	Ave. Price/ton
1994	1,353	$4.90
1995	1,386	$4.87
1996	1,463	$4.91
1997	1,562	$5.15
1998	1,650	$5.33

Period	production growth (% change)	Price change (%)
1994-1995	+2.4%	+0.6%
1995-1996	+5.6%	+0.8%
1996-1997	+6.8%	+4.9%
1997-1998	+5.6%	+3.5%

National Dense Aggregate Market

- The harbors identified with significant disposal needs are also experiencing dramatic growth.
- HarborRock will be building sustainable aggregate manufacturing plants in the heart of the urban growth areas.

Table showing regional crushed dense stone sales in 1998 and the percent change in first quarter 1999 sales to the same period in 1998.

Region	Tons Sold (,000s) 1998	Value ($,000s) 1998	Price/ton	Volume % Change
Northeast	217,360	$1,317,000	$6.06/ton	-0.7%
S. Atlantic (Virginia)	388,300	$2,290,000	$5.90/ton	+14.4%
Mountain (California)	58,410	$312,000	$5.34/ton	+17.5%
Pacific (Washington)	100,430	$580,000	$5.78/ton	+18.3%

National Cement Market

- Cement is the binding agent in concrete. Its production and consumption are fundamental indicators for the country's construction industry.
- Concrete is made by a proportion of approximately 1 part cement, 2 parts sand and 4 parts aggregate, such as LWA.
- The USGS projections are for cement production to increase by approximately 2% per year.

The following USGS figures show that the production of cement and the corresponding need for aggregate continues to rise.

Year	Cement Production (000's of tons)	Price $/ton
1994	95,124	$67.39
1995	94,603	$74.66
1996	99,391	$78.31
1997	105,620	$80.84
1998	113,300	$82.50
1999	119,981 (projected)	Not available

Period	Production Growth (% change)	Price change (%)
1994-1995	-0.55%	+10.79%
1995-1996	+5.06	+4.89%
1996-1997	+6.27%	+3.23%
1997-1998	+7.27%	+2.05%
1998-1999 (projected)	+5.90%	NA

Cost Advantages of using LWA

- Specifying and using lightweight aggregate masonry blocks results in greater labor productivity, superior performance and lower total wall cost.
  - Productivity goes up when lighter weight blocks are used.
  - Block units weighing 37 pounds or more require 2 man crews to install.
  - The greater the length of the block, the greater the productivity.

Concrete Masonry Unit Weights (pounds)		
Block Size (in.)	Lightweight Blocks	Typical Heavy-Weight Blocks
8x8x16”	23-26	37
12x8x16”	32-35	52 (2-man block)
8x8x24”	32-35	52 (2-man block)

Productivity Comparison of using a 24 “ Lightweight block vs. a 16’ Heavyweight Block – one man block crews

Size	Type	Courses	Seconds/unit	Blocks/HR	Rate SQ.FT/HR	Rate Change
16”	HW	Avg. of 6	47.8	75.3	66.9	
24’	LW	Avg. of 6	43.5	82.8	110.4	+64.9%

Cost Advantages of using LWA

This analysis indicates the savings that can be realized by using lightweight aggregate concrete versus typical dense aggregate concrete in the initial design of the structure.

U.L. DESIGN NO. D-916 Non-Composite Steel Design, Category I									
BAY SIZE	20' X 20' - 400 SF			24' X 24' - 576 SF			30' X 30' - 900 SF		
CONCRETE TYPE	NORMAL WEIGHT	SEMI-LTWT.	LIGHT-WEIGHT	NORMAL WEIGHT	SEMI-LTWT.	LIGHT-WEIGHT	NORMAL WEIGHT	SEMI-LTWT.	LIGHT-WEIGHT
CONCRETE STRENGTH	3500	3000	3000	3500	3000	3000	3500	3000	3000
CONCRETE DEPTH	4 1/2"	3 1/2"	3 1/4"	4 1/2"	3 1/2"	3 1/4"	4 1/2"	3 1/2"	3 1/4"
CU. YD/BAY	6.79	5.56	5.24	9.77	8.00	7.55	15.27	12.50	11.80
2" METAL DECK, GA.	22	22	22	20	20	22	20	20	22
STRUCT. STEEL, TONS	1.100	1.060	1.060	1.860	1.776	1.776	4.260	3.885	3.810
TOTAL LOAD KIPS/BAY	28.90	21.30	18.90	43.20	30.70	27.70	70.30	50.30	45.30
TOTAL LOAD LBS./S.F.	72.25	53.25	47.25	75.00	53.30	48.09	78.11	55.89	50.33
CONCRETE MATERIALS, $	348.00	352.00	332.00	501.12	506.88	478.08	783.00	792.00	747.00
CONCRETE INST-ALLATION, $	308.00	316.00	304.00	443.52	455.04	437.76	693.00	711.00	684.00
REINFORCE STEEL, $	92.00	92.00	92.00	132.48	132.48	132.48	207.00	207.00	207.00
METAL DECK,$	416.00	416.00	416.00	656.64	656.64	656.64	1026.00	1026.00	1026.00
STRUCTURAL STEEL, $	1320.00	1272.00	1272.00	2232.00	2131.20	2131.20	5112.00	4662.00	4572.00
FIRE-PROOFING, $	316.96	267.96	267.96	354.16	353.78	353.78	664.32	316.54	309.7
TOTAL COST $/BAY	2800.96	2715.96	2683.96	4319.92	4236.02	4132.34	8485.32	7714.54	7455.70
TOTAL COST $/S.F	7.002	6.790	6.710	7.500	7.354	7.174	9.428	8.572	8.284
SAVINGS $/BAY		85.00	117.00		83.90	187.58		770.78	1029.62
SAVING, $/S.F		0.212	0.292		0.146	0.326		0.856	1.144
SAVINGS/YARD*		25.20	31.65		20.88	33.90		67.41	90.62
Premium dollars available per cubic yard of lightweight concrete to equal cost of using normal weight concrete.									
Additional savings found in columns and foundations are not included.									

Advantages of HarborRock to its Competitors

- Fuller Company, a large U.S. provider of kiln technology, has manufactured LWA samples for HarborRock from dredge materials across the country with superior results.

- HarborRock, according to Fuller Company, would be the best commercial product on today's market.

- Unlike LWA produced by expanding mined shale, extruded LWA has uniform properties and consistent strength.

- Fuller or Svedala Industries will guarantee process, will work exclusively with HarborRock using proven, proprietary technology, and will issue standby letters of credit on a project by project basis.

- Process is state of the art, environmentally sound, and can be replicated.

Comparison of Existing Commercial LWA to HarborRock

The chart below shows HarborRock to be lighter yet stronger than the average commercial product on the market today.

Plant	Density (lbs/cf)	Crush strength (lbs.)
A	56.9	131
B	50.7	177
C	41.0	197
D	34.1	128
E	34.1	120
F	41.7	122
G	47.5	197
H	38.2	183
I	35.0	165
Commercial Average	**42.1**	**158**
Delaware	**35.1**	**175**
New Jersey	**33.4**	**171**
San Francisco	**36.0**	**169**
Seattle	**28.3**	**215**

Marketing & Sales Advantages of LWA vs. Dense Aggregate

◈ HarborRock's LWA plants will be in the heart of the urban market areas:
- Raw material is a renewable, sustainable resource.
- Location ensures low transportation cost to market.
- Profit margins are obtained from disposal tip fees and LWA sales, at greater amounts than dense aggregate suppliers.

◈ The HarborRock LWA will be marketed and sold to:
- Architects and engineers who specify materials used in buildings.
- Concrete block manufacturers.
- Asphalt manufactures.
- Federal and State departments of transportation.

◈ Sales strategies will include:
- Promoting the cost benefits and labor savings of using lightweight, high strength aggregate purchased at competitive prices.
- Marketing as a "recycled" product helping consumers meet buy recycled mandates.
- Demonstrating that the product quality and supply is consistent and equal to or better than the competition.

5

USGS

Eastern Mineral Resources

Mid-Atlantic Geology and Infrastructure Case Study

Issues

The successful integration of natural resource information into land-use decisions is becoming increasingly important as the competition for land and resources becomes more complex, frequent, and urgent. Continued population growth and urbanization, particularly in the eastern United States where existing infrastructure is deteriorating and needs replacement, will generate huge demands for construction materials. Sand, gravel, and crushed stone aggregate are the materials with which our cities are built and maintained Because both geologic and economic market conditions dictate the location of recoverable aggregate and construction raw materials, the ability to meet the future demand of the construction industry will be controlled by the availability of the resource.

Current production of aggregate in the Nation exceeds 2 billion tons. On the basis of either weight or volume, aggregates accounted for over two-thirds of the approximately 3.3 billion tons of non-fuel minerals mined in the United States in 1995.

The trend in production for both sand and gravel and crushed stone from 1995 at a conservative average growth rate of 0.5% and 1% respectively, can be projected for the next 25 years - the first quarter of the next century.

From a cumulative production perspective, the amount of crushed stone to be produced in the next 20 years will equal the quantity of all stone produced over this past century, approximately 76 billion tons. Combined with the projected cumulative production of sand and gravel, the total amount of aggregate to be mined in the next 25 years will be equivalent to almost all of the aggregate mined in this country in the past 100 years. While these are simple projections, and may not be a very precise forecast of the future, they do suggest the likelihood that vast quantities of both crushed stone and sand and gravel will be needed, much of it from resources yet to be delineated or defined.

Growth in many urban areas has depleted natural aggregate resources or rendered potential deposits inaccessible. As a result, many large urban areas are increasingly confronting both limited resources and limited space for growth. For the first time in our history, large quantities of aggregates, which in the past were generally acquired within 30 milcs of the market, are being imported in ever increasing quantities. The regional earth-science information presently available to decision makers charged with meeting this infrastructure resource challenge is, by and large, inadequate.

As the demands for stone products continue to increase, particularly in the more densely populated areas of the country, such as the Baltimore-Washington corridor and the Colorado Front Range, serious concern and attention must be given to the concept of multiple competing land-use. There is no substitute for the use of crushed stone and other natural aggregate in the construction industry. * Provisions for adequate, uninterrupted, economical supplies of aggregate will have to be made in order to insure that supplies will keep up with demand.

(From: Hayden, J.S., Langer, W.H., Robinson, G.R., Jr., and Tepordei, V.V., 1997, Access to Crushed Stone: the East and Front Range : Extended Abstracts with Technical Program, 1997 Society for Mining, Metallurgy, and Exploration Annual Meeting, February 24-27, Denver, Colorado, 9p.)

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This page is URL: http://minerals.usgs.gov/east/magic/issues.html
Maintained by jback@usgs.gov
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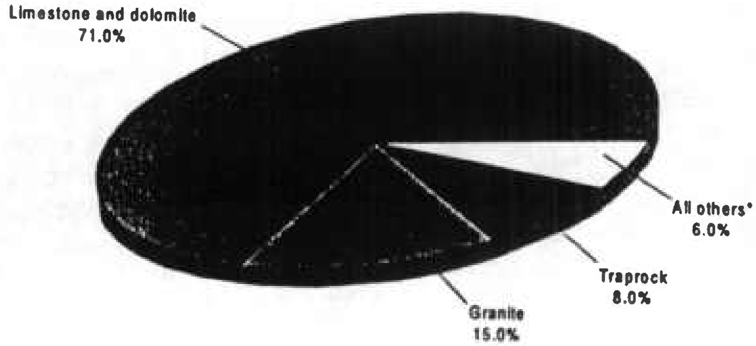
Natural Aggregates—Foundation of America's Future

Natural aggregates, which consist of crushed stone and sand and gravel, are among the most abundant natural resources and a major basic raw material used by construction, agriculture, and industries employing complex chemical and metallurgical processes. Despite the low value of the basic products, natural aggregates are a major contributor to and an indicator of the economic well-being of the Nation.



*Includes (in descending order of production) sandstone and quartzite, miscellaneous stone, marble, calcareous marl, slate, shell, and volcanic cinder and scoria.

U.S. crushed stone production, by kind of stone.

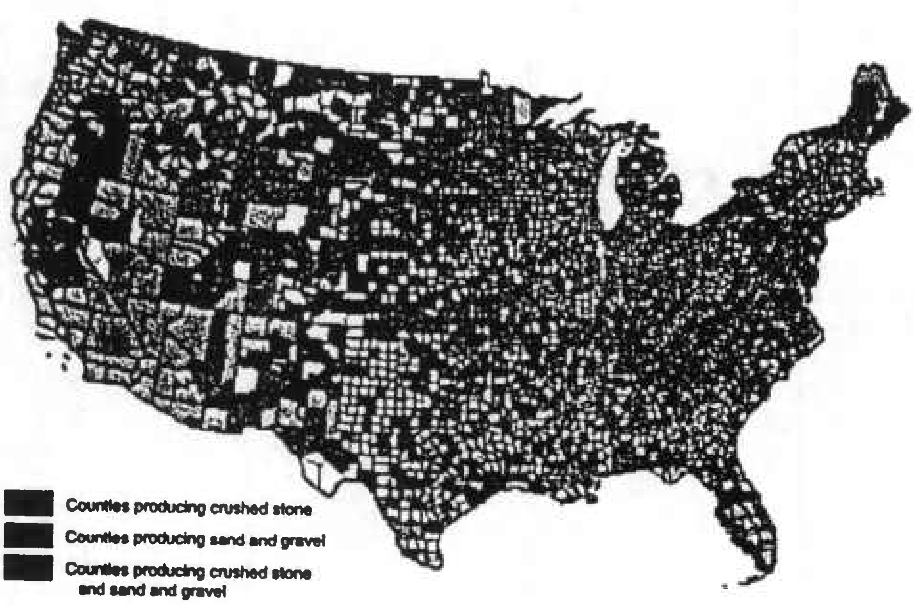
Various Uses of Aggregates

Aggregates have an amazing variety of uses. Imagine our lives without roads, bridges, streets, bricks, concrete, wallboard, and roofing tiles or without paint, glass, plastics, and medicine. Every small town or big city and every road connecting them were built and are maintained with aggregates. More than 90 percent of asphalt pavements and 80 percent of concrete are aggregates. Paint, paper, plastics, and glass also require sand, gravel, or crushed stone as a constituent. When ground into powder, limestone is used as an important mineral supplement in agriculture, medicine, and household products. Aggregates are also being used more and more to protect our environment. Soil erosion-control programs, water purification, and reduction of sulfur dioxide emissions generated by electric powerplants are just a few examples of such uses.

Growth in Aggregates Demand

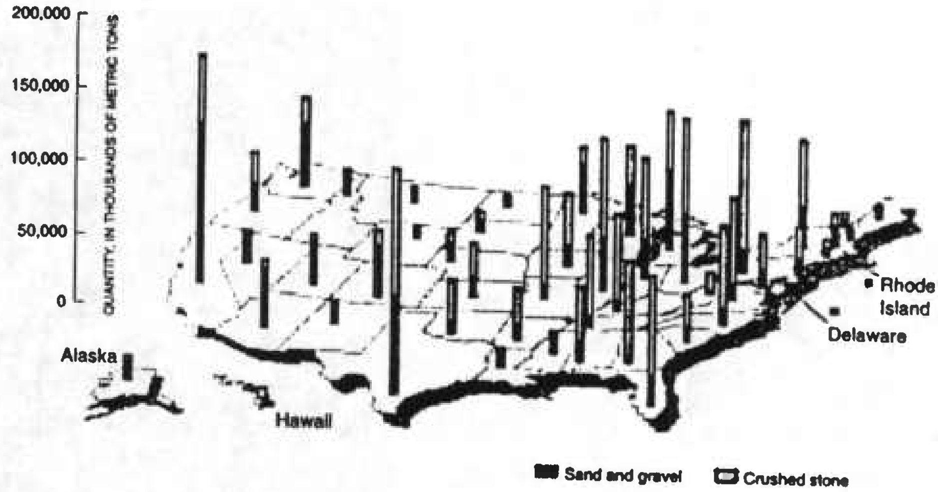
One way to understand and appreciate better the importance of the aggregates industries is to look at their production in the context of all mining. On the basis of either weight or volume, aggregates accounted for more than two-thirds of about 3.3 billion metric tons of nonfuel minerals produced in the United States in 1996. When coal mining is included, the amount of crushed stone and sand and gravel produced still accounts for more than one-half of the volume of all mining and more than twice the amount of coal produced. In this century, the production of aggregates increased from a modest total of about 58 million tons in 1900, when the collection of production statistics began, to 2.3 billion tons in 1996 (Bolen, 1996; Tepordei, 1996). The 1996 annual production of crushed stone and construction sand and gravel was the highest ever recorded in the United States for these mineral commodities. It is important to note that of the total natural aggregates produced in this century, more than one-half was produced and consumed in the last 25 years.

Of the crushed stone produced in the United States, limestone and dolomite account for 71 percent; granite 15 percent; and gabbro, basalt, and diabase, also known as traprock, 8 percent. The remaining 6 percent of the crushed stone produced comprises sandstone, quartzite, marble, calcareous marl, slate, shell, and volcanic cinder and scoria.



U.S. counties producing natural aggregates.

The production of natural aggregates is closely related to the population and the level of industrial development of a specific area. The major aggregates-producing States, based on 1996 data, were Texas, California, Ohio, Pennsylvania, and Illinois, in descending order. The 1996 U.S. per capita consumption of aggregates was 8.7 metric tons. The State per capita consumption of aggregates varied from highs of 28.7 tons in Alaska, 20.7 tons in South Dakota, and 17.6 tons in Iowa, to lows of 3.8 tons in Connecticut and 3.3 tons in Louisiana.



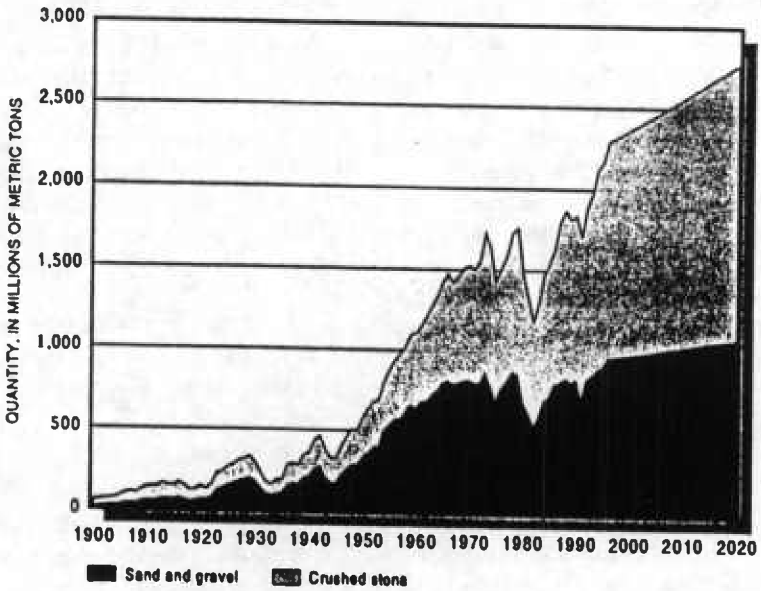
Production of natural aggregates, crushed stone and sand and gravel, by State.

The production of recycled aggregates, mostly from concrete and asphalt pavements, has also been increasing in recent years. Replaced and reconstructed old roads and buildings have become major sources of "recyclable materials." In some applications, recycled aggregate can compete with natural aggregates on price and quality. The increasing limitations imposed on the use of landfills, as well as the higher costs imposed on their use, are making the recycling of aggregates economically viable.

Continuous Growth into the Next Century

As we attempt to forecast the level of production of aggregates, we have to look back first. During the past 25 years, production of crushed stone has increased at an average annual rate of about 3.3 percent. Production of sand and gravel, which until 1974 exceeded that of crushed stone, has increased at an annual rate of less than 1 percent. The construction of the Interstate Highway System, which became the National Highway System, was one of the major reasons for this growth. By using very conservative assumptions, we have projected trends in the production of crushed stone and sand and gravel at average annual growth rates of 1 percent and 0.5 percent respectively.

Based on these assumptions, by 2020 U.S. production of crushed stone, which is expected to increase by more than 20 percent, will be about 1.6 billion metric tons, while production of sand and gravel will be just under 1.1 billion metric tons, an increase of 14 percent. The amount of crushed stone to be produced in the next 20 years will, therefore, equal the quantity of all stone produced during this century, about 36.5 billion metric tons. Combined with the projected cumulative production of sand and gravel, the total amount of aggregates to be mined in the next 25 years will be equivalent to almost all the mining that has taken place in this country for these materials in the past 100 years. These projections suggest that vast quantities of crushed stone and sand and gravel will be needed in the future and that much of it will have to come from resources yet to be delineated or defined. Therefore, interdisciplinary scientific studies specifically relevant to the aggregates industry will be needed even more in the future.



National aggregates production in the United States with projections to 2020, based on growth rate of 1.0% for stone and 0.5% for sand and gravel.

Working With, Not Against, Nature

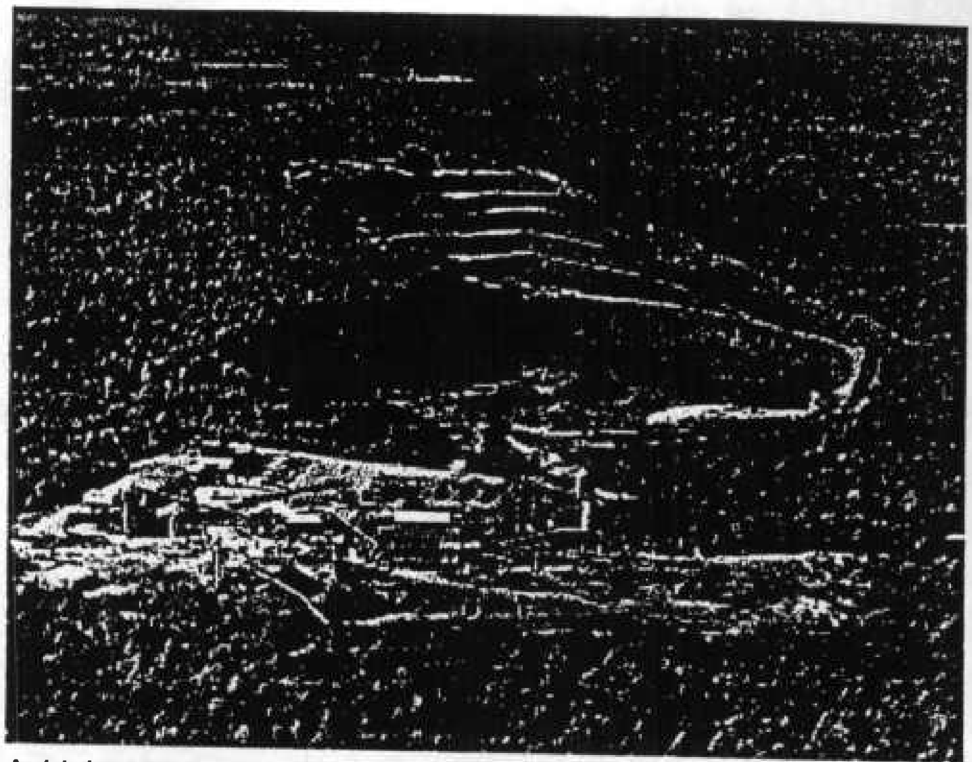
Today, we recognize that Earth's resources, however vast, are finite. We also realize that everything we use must start with raw materials that are grown or mined. We also understand that wise stewardship of the environment is necessary to preserve natural resources for future generations. To that end, the crushed stone and sand and gravel producers have to meet all environmental regulatory requirements, and are encouraged to exceed what the laws and regulations require. Consequently, their work is planned with a clear understanding of their role in conservation and land reclamation. The results of successful reclamation projects can be seen around the country in housing subdivisions, shopping malls, community parks and lakes, golf courses, and wildlife refuges.

Caring about the environment and providing essential products are only part of today's aggregates producers' commitment to their communities. More than 90,000 employees and their families depend on the aggregates industries for their livelihood, and thousands more work in related industries that use this valuable natural resource or its byproducts.

USGS—The Major Source of Information on Natural Aggregates

For more than 100 years, the U.S. Geological Survey (USGS) has been the major source of information on the Nation's natural resources. In 1996, the USGS's capabilities to provide relevant, objective, and timely information on production, location, quality, and availability of natural resources were enhanced by the addition of minerals information specialists from the former U.S. Bureau of Mines. Today, the USGS is uniquely positioned to assist Federal, State, and local government organizations, schools and universities, private industry, interest groups, and the general public by providing information on the Nation's natural resources.

USGS mineral commodity specialists keep track of developments in the U.S. and international mineral industries. Information about the production, consumption, and recycling of minerals from U.S. companies, mines, and mineral-processing plants is collected, processed, analyzed, and published. Annual and quarterly reports on the production for consumption of natural aggregates, as well as directories of principal producing companies, are published and distributed in print and electronic form. Most of this information is available as printed reports and on CD-ROM. It can also be accessed immediately through a fax-on-demand system, MINES FaxBack, or on the World Wide Web. The geologic occurrences of potential sources of crushed stone and sand and gravel that may be used as natural aggregates in the conterminous United States are discussed in USGS Bulletin 1594 (Langer, 1988) and in USGS Circular 1110 (Langer and Glanzman, 1993).



Aerial view of the Suzio York Hill crushed stone quarry located near Meriden, Conn.

Special USGS Projects on Aggregates Resources and Urban Growth Issues

Infrastructure, such as roads, airports, utilities, and many other facilities, is vital to the growth of any populated area. Much of the Nation's infrastructure built during the 1950's and 1960's has deteriorated. In many areas of rapid population growth, the infrastructure is becoming inadequate, and new roads, streets, and sewage systems must be built to meet the increased needs. Maintenance and development of the infrastructure requires large volumes of natural aggregates. As urban areas expand, local sources of these resources are becoming less accessible. Resources that are unavailable locally must be brought in from more distant sources, often at greater costs that are passed on to the public as higher taxes or reduced services.

The successful integration of natural resource information into land-use decisions is increasingly difficult as the competing needs for lands and resources become more numerous, complex, and urgent. In response to these issues, the USGS has initiated special projects to increase better understanding of the natural resource needs and issues of urban areas.

Rocky Mountain Front Range Infrastructure Resources Project

In rapidly growing areas along the Rocky Mountain Front Range urban corridor, resource use often competes with other land uses and may be preempted by government mandates in response to local issues. The Rocky Mountain Front Range Infrastructure Resources Project began in 1997 and is being conducted in the urban corridor from Cheyenne, Wyo., to Pueblo, Colo. Initially, the project is focusing on a demonstration area in the northern part of the urban corridor and will address problems of sustaining the availability of infrastructure resources (natural aggregates, water, and energy) in rapidly growing areas along the Rocky Mountain Front Range urban corridor.

The principal goals of the project are as follows:

- Implementing a multidisciplinary evaluation of the region's infrastructure resources.
- Determining the region's projected needs for infrastructure resources.
- Identifying the issues that may affect the availability of resources.
- Providing decisionmakers with tools to evaluate alternate methods for sustaining infrastructure resources.

Mid-Atlantic Geology and Infrastructure Case Study

Sand and gravel and crushed stone used as construction aggregates are mined near urban and rapid-growth areas because the marketplace is the urban environment and the materials are costly to transport. For example, the Baltimore-Washington urban corridor is one of the Nation's fastest growing metropolitan areas, with more than 7 million people spread over 39 counties and the District of Columbia. This area, with historic high levels of production of construction materials and significant changes in resources and urban development, is typical of the mid-Atlantic region. It also provides insights into the likely future trends in other areas of the Nation. Consequently, this corridor was chosen for a USGS case study to document the regional trends in the production and the availability of aggregates and the development of infrastructure.

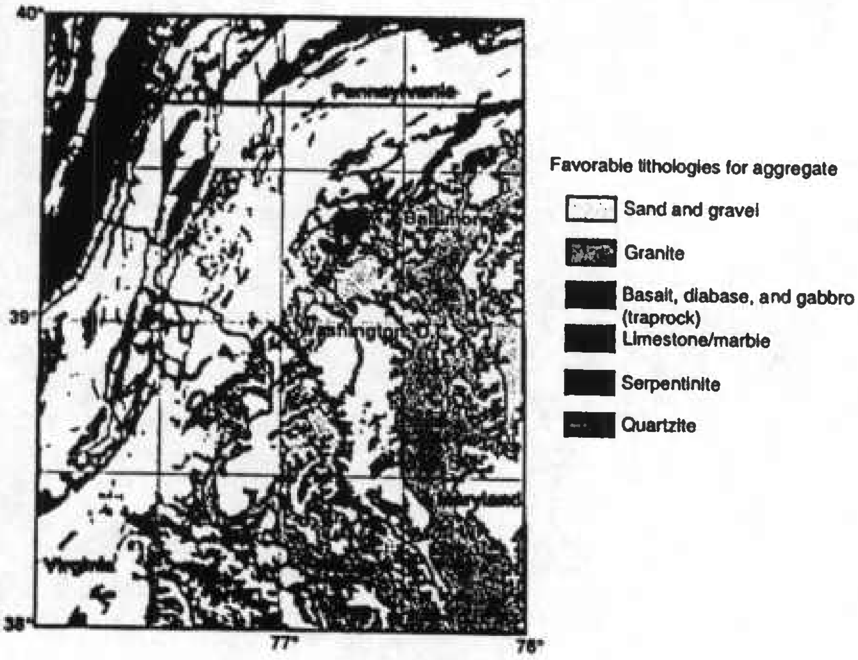
The objectives of the regional case study are as follows:

- Identification of the main geologic sources and locations of quality construction resources in the region.
- Documentation, by county, of the amount of aggregates produced and used in the region, who produces aggregates, who uses aggregates, and how much is consumed.
- Analysis of aggregates production and demographic information.
- Development of a regional aggregates resource demand forecasting tool.
- Analysis of anticipated availability of aggregates as reflected in county-level management planning.

Summary

Natural aggregates are widely distributed throughout the United States and occur in a variety of geologic environments, however, they are not universally available. Some areas lack quality aggregates, or existing aggregates deposits cannot be mined for a multitude of reasons; but economic factors require that pits or quarries be located near the population centers. However, residential communities usually require that mining of aggregates be conducted far from their boundaries.Thus, competing land-use plans, zoning requirements, and various regulations frequently prohibit extraction of aggregates near populated areas.

Because the demand for aggregates will continue and, most probably, will grow in the future, provisions to assure adequate supplies will have to be made. Long-range planning and zoning regulations will have to take into account current and future community needs for this valuable natural resource. All groups and individuals will need to work together to ensure adequate community and environmental protection, while ensuring the availability of aggregates at a reasonable cost that will allow growth and prosperity.



Study area for the Mid-Atlantic Geology and Infrastructure Case Study in the Baltimore-Washington urban corridor.

References

Bolen, W.P., 1997, Construction sand and gravel: U.S. Geological Survey Minerals Yearbook 1995, v. 1, p. 703-714.

Langer, W.H., 1988, Natural aggregates of the conterminous United States: U.S. Geological Survey Bulletin 1594, 33 p.

Langer, W.H., and Glanzman, V.M., 1993, Natural aggregate—Building America's future: U.S. Geological Survey Circular 1110, 39 p.

Tepordei, V.V., 1997, Crushed stone: U.S. Geological Survey Minerals Yearbook 1995, v. 1, p. 783-809.

Information

More information on natural aggregates can be found on the Internet at:
http://minerals.er.usgs.gov/minerals
http://webserver.cr.usgs.gov/frirp/FRIRP.html

or by fax from
MINES FAXBACK at (703) 648-4999

Valentin V. Tepordei
Graphic design by Kristen L. Hayes and Lendell Keaton

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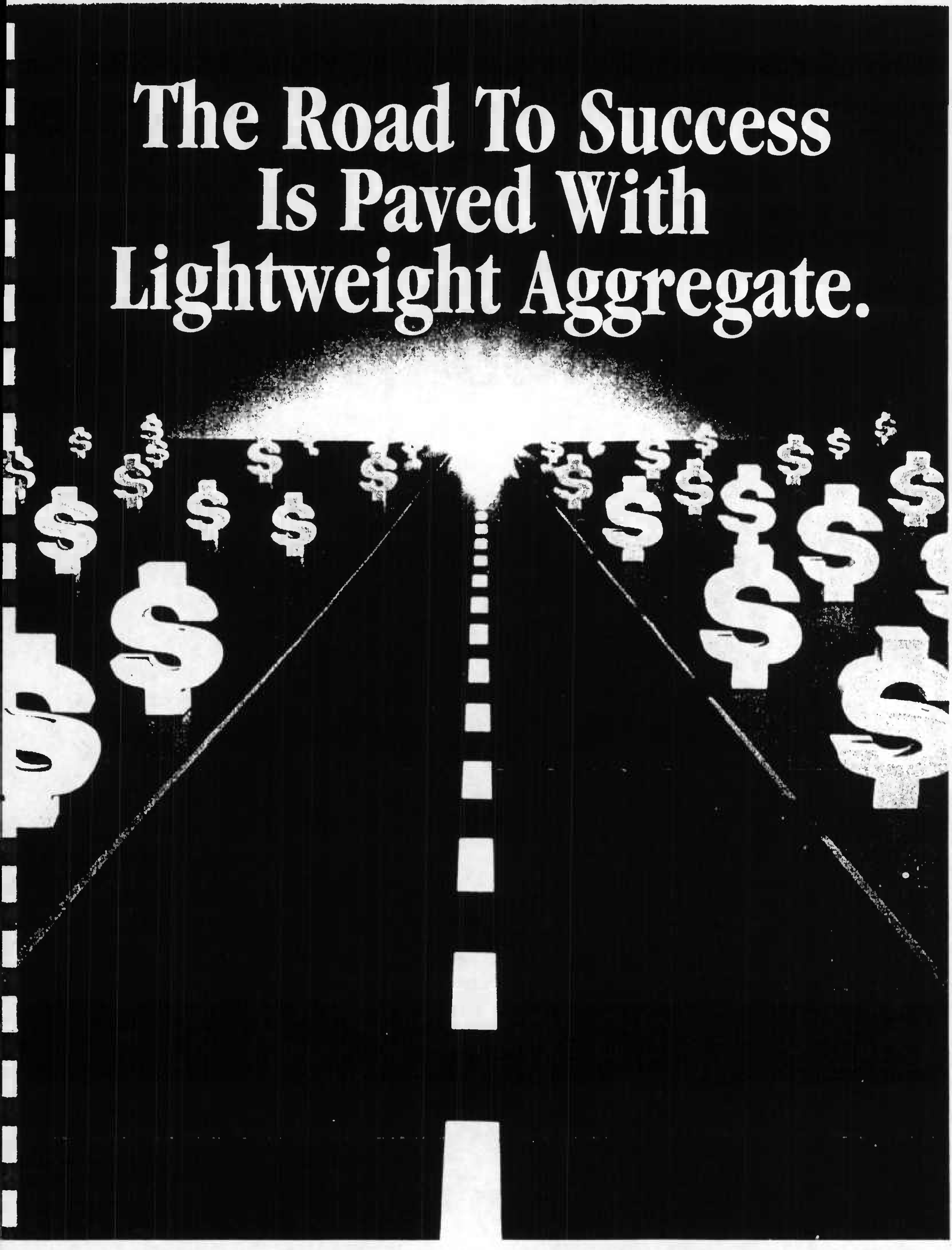
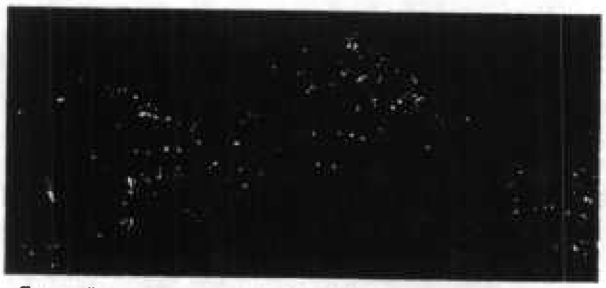

The Road To Success
Is Paved With
Lightweight Aggregate.

Lightweight Aggregate Paves the Way for Safe and Economical Roads.

When Choosing the Right Pavement Material, the Road Leads to Lightweight Aggregate.

Expanded Shale, Clay and Slate Lightweight Aggregate (LWA) has been used on all types of roads (rural, city and freeways) with proven superior performance. First introduced to the asphalt market over thirty years ago, the use of LWA currently exceeds 3,000 miles annually in the United States alone. LWA has been used in over twenty states with total installed costs competitive to normal weight aggregates yet with far more advantages.



From a fiery rotary kiln comes lightweight aggregate processed in varying gradations and textures.

What is Lightweight Aggregate?

Expanded Shale, Clay and Slate Lightweight Aggregate has a long track record of quality and performance. Since its development in the early 1900s, LWA produced by the rotary kiln process has been used extensively in asphalt road surfaces, concrete bridge decks, high-rise buildings, concrete masonry and geotechnical applications. The quality of LWA results from a carefully controlled manufacturing process.

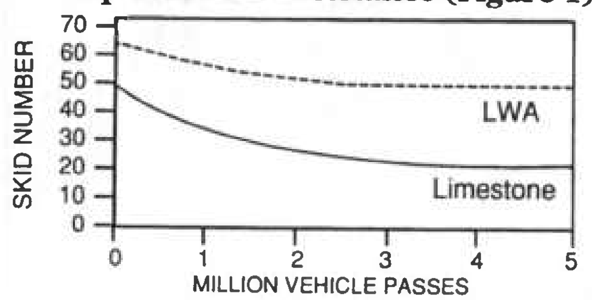
In a rotary kiln selectively mined shale, clay or slate is fired in excess of 2000° F. The LWA material is then processed to precise gradations. The result is a high quality, lightweight aggregate that is inert, durable, tough, stable, highly insulative and free draining, ready to meet stringent structural specifications. When bonded to asphalt it creates an advanced road surface that is safer, more economical and longer lasting than its normal weight aggregate counterpart.

Lightweight Aggregate Can Save Lives.

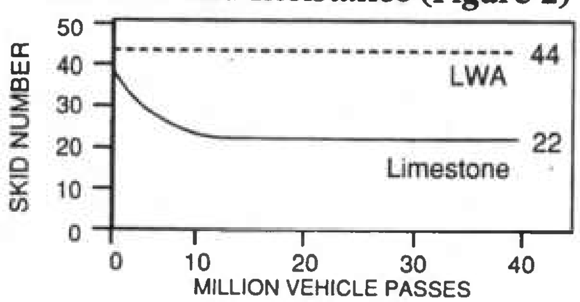
Safety is increased due to the superior skid resistance (wet or dry) of road surfaces made with LWA. This high skid resistance (Fig.1 & Fig.2) is maintained throughout the road's service life because of the aggregate's rough micro surface texture. Pavements made with normal weight aggregates (especially those using limestones, dolomites and gravel) may polish or become slick under the action of traffic and lose a large percentage of their skid resistance. Lightweight aggregates do not polish as they wear. LWA pavement maintains its high skid resistance because under wear, fresh interior cells with rough ceramic-like edges are continually exposed.

All tires sold in the United States are certified for friction compliance on a hot-mix LWA pavement built for the Federal Highway Safety Administration in San Angelo, Texas. Lightweight hot mix was chosen for its constant high friction and durability.

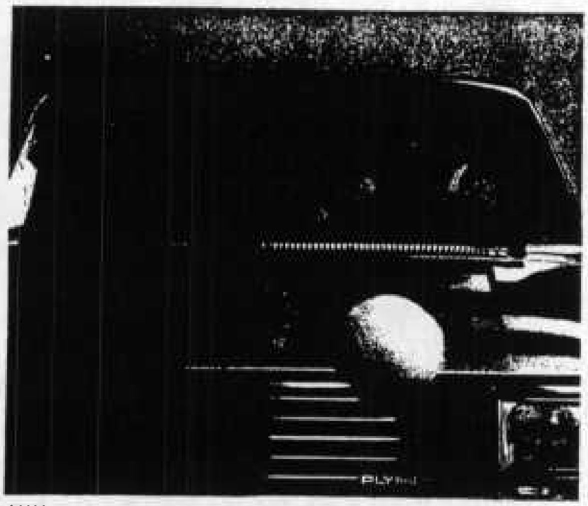
Chip Seal Skid Resistance (Figure 1)



Hot Mix Skid Resistance (Figure 2)



Notes:
Information provided by the Texas Department of Transportation, District II, and the Texas Transportation Institute. **Figure 1:** --- 100% Lightweight Chip Seals. This plot represents over 100 skid tests with each test representing up to 6 data points. —— 100% Limestone Chip Seals. This plot represents over 75 skid tests with each test representing up to 6 data points. **Figure 2:** --- Hot mixed asphalt concrete uses 100% lightweight expanded shale, clay or slate as the coarse aggregate. This plot represents approximately 200 skid tests with each test representing up to 6 data points. —— Hot mixed asphalt concrete uses 100% limestone as the coarse aggregate. This plot represents approximately 100 skid tests with each test representing up to 6 data points.

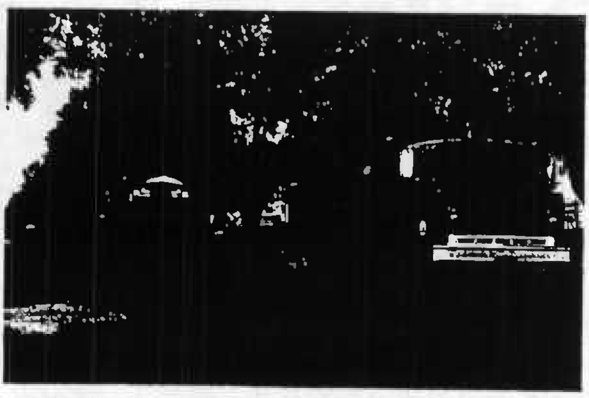


LWA pavement helps save automobile fatalities and injuries due to superior skid resistance, wet or dry.

Lightweight Aggregate Makes Tax Dollars Go Farther.

The roadway service life is extended because of LWA's unique and superior bonding capabilities with asphalt. When bonded to the asphalt, lightweight aggregate presents a tough, durable pavement that holds up well under traffic and outlasts most pavements made with normal weight aggregate. LWA has minimal dust unlike normal weight aggregate that is often coated with dust that prevents uniform bonding and creates public complaints during application. Lightweight aggregates consistently pass Los Angeles Abrasion Requirements as well as other quality tests. LWA also shows superior "freeze-thaw" resistance and durability to de-icing salt corrosion. If snow plow damage occurs, LWA is far more resistant to being stripped out than normal weight aggregate.

Lightweight aggregate is the proven solution for cost-sensitive highway and road departments. LWA offers lower direct and indirect costs over the service life of the road and is the reason more state and local transportation departments are specifying LWA.



Lightweight aggregate bonds uniformly to asphalt to create a safe and durable road surface.

LWA offers more than twice the volume for the same weight of conventional aggregates.

Many Cost Advantages in Transport and Construction.

Δ Material haul costs are reduced because LWA weighs about half that of normal weight aggregate thus allowing for a much larger volume of material per truck load and less overall tonnage to be hauled.

Δ Contractors consistently report fewer breakdowns because of less equipment wear and tear.

Δ LWA is much easier to hand-broadcast.

Δ Chip seal projects are safer because there are fewer and less dangerous flying particles caused by passing vehicles. Windshield damage claims are practically eliminated.

Δ Brooming or vacuuming excess chips from chip seal projects is much easier with LWA.

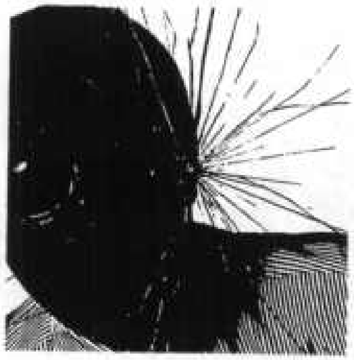
Δ Lightweight aggregate is easily pre-wetted and will hold moisture for days in a stockpile providing an almost dust-free placement – a plus when emulsions are used with chip seals.

Δ Lightweight aggregate is readily available throughout the U.S., Canada and much of the world.

Δ The contractor can use the same machinery and equipment as with normal weight aggregate with one exception: only use pneumatic rubber-tire rollers with chip seal projects (no steel-wheel rollers).

Lightweight Aggregate is the Preferred Pavement Choice, Regardless of Application.

Chip Seal



This surface treatment is referred to by several names depending on the local area. The most common name is chip seal, however, other names like seal coat, surface treatment, inverted penetration, oil and chip, chip and seal, and armor coat are also used.

Chip seals are made by spraying a layer of asphalt emulsion or hot liquid asphalt, covering it with aggregate and then rolling it. Only pneumatic rubber tire rollers are used with LWA.

Any chip seal application has some non-embedded loose stones that can be picked up by a tire and sent "flying". Damage to windshields, headlights and paint caused by "flying" stones is practically eliminated with LWA thus avoiding those costly insurance claims and motorist complaints. The lightness of the LWA plus the higher wind resistance of the rough surface texture lowers the speed at impact. The resulting striking force is too small to do damage. The rough surface texture also bonds to the asphalt better so there are fewer "flying" particles in the first place.

Chip seal paving is a low cost durable surface treatment since it uses less materials and is not premixed at the asphalt plant or job site. This type of surface treatment is normally used on low-volume rural roads or city streets. However, because of its high skid resistance, superior bonding capability and lack of vehicle damage, LWA chip seals have been used on high-speed/high-volume city streets and highways such as the Autobahn in Germany and Interstate highways in the United States.

Lightweight chip seals offer the engineer an economical, long lasting road surface that is safer to drive on and free of motorist complaints.

Plant Mix Seal Overlay or Open-Graded Friction Coarse

This application uses uniformly-sized aggregate. The material is first pre-blended in a drum mix plant using excess oil. The mixture is sent to the job site hot and is put down with a standard laydown machine. The finished road surface has a coarse open-graded texture that is very durable with excellent drainage and skid resistance.

LWA plant mix seals are often used to overlay existing pavement after extensive repairs have been made.

Plant mix seals are very effective on high-volume/high-speed roadways and, because of the open texture, they offer a quieter ride and much less water spray from moving vehicles especially trucks. This type of surface design is quieter because percussion cups are eliminated by the open surface.

Hazardous truck spray and splash from regular dense-graded surface.

Open-graded plant mix surface without spray and splash.

Hot Mix Surface Coarse

Hot mix, the premier asphalt surface alternative, is much denser and a tighter graded mixture that is usually a blend of LWA and normal weight aggregates. This material is shipped hot and laid down using conventional methods.

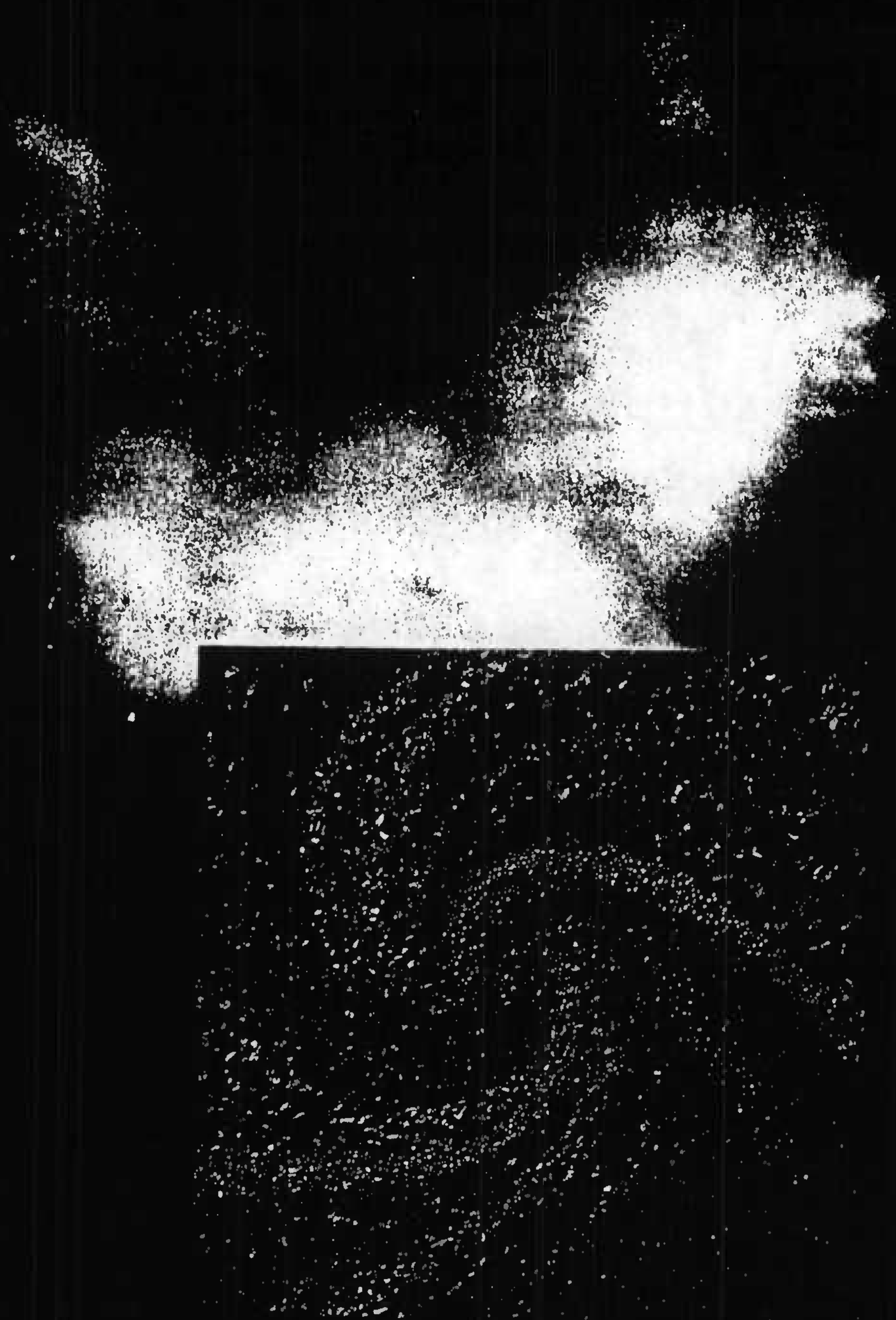
LWA hot mixes have performed successfully on freeways with high truck traffic. Increased skid resistance and extended performance life makes LWA hot mixes a preferred choice.

Micro-Surfacing (Slurry Seal)

Micro-surfacings are useful in stopping the deterioration of an oxidized asphalt surface and the various types of problems that occur with weathering. Fine-graded LWA works well in slurry seals and micro-surfacing, and improves skid resistance.

Cold Mix – Pothole Patch

LWA is versatile in cold mix form because it has a tenacious bond with asphalt. Since it has a lower heat capacity than normal weight stone, LWA can be used in deep pothole patching applications.

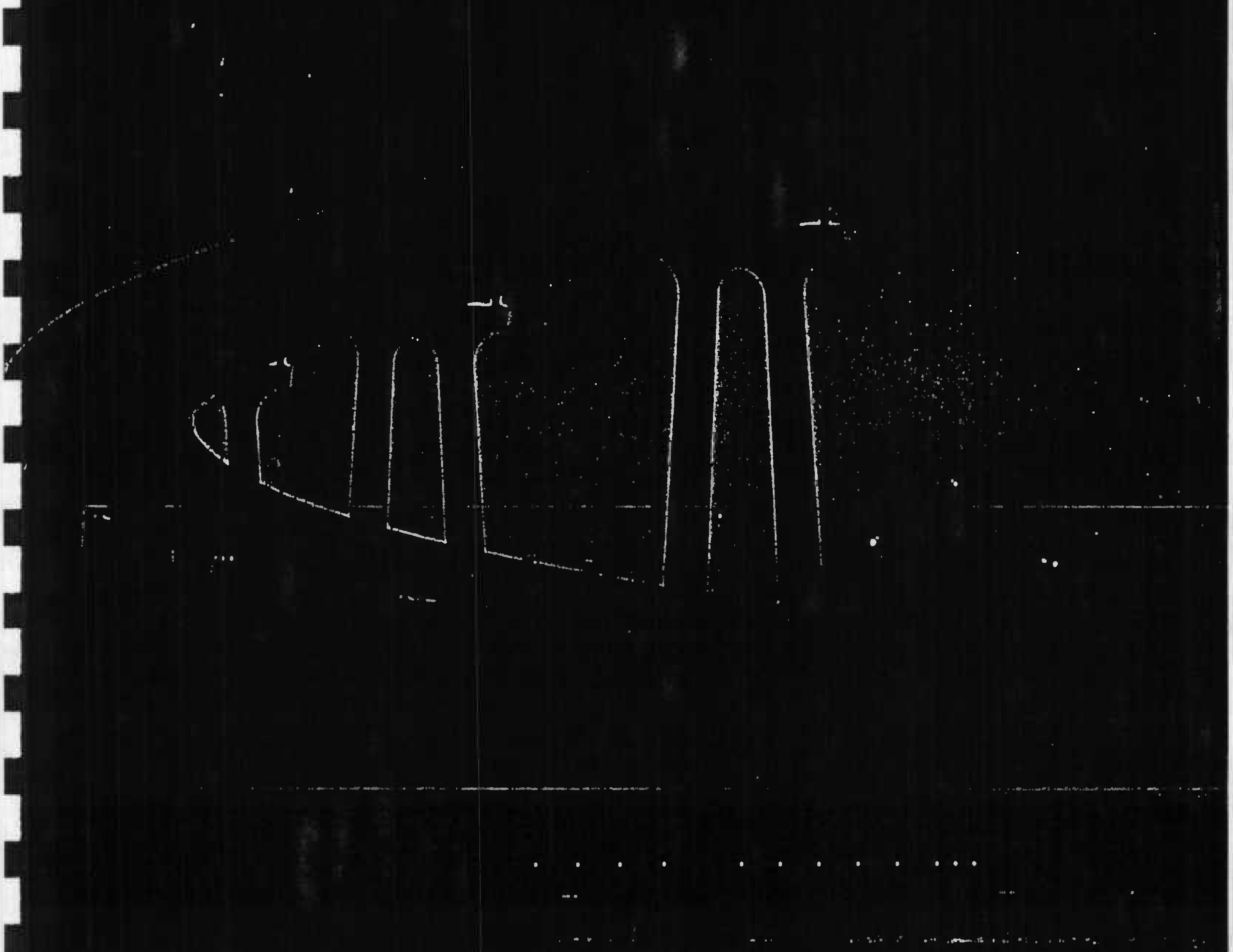


Lightweight Aggregate. From Stone Age to a Modern Age of High Tech Performance.

In a rotary kiln, selective shale, clay or slate is fired in excess of 2000° F; then processed to exacting gradations and specifications for today's modern roads and highways.

Building Bridges...

With Structural Lightweight Aggregate Concrete



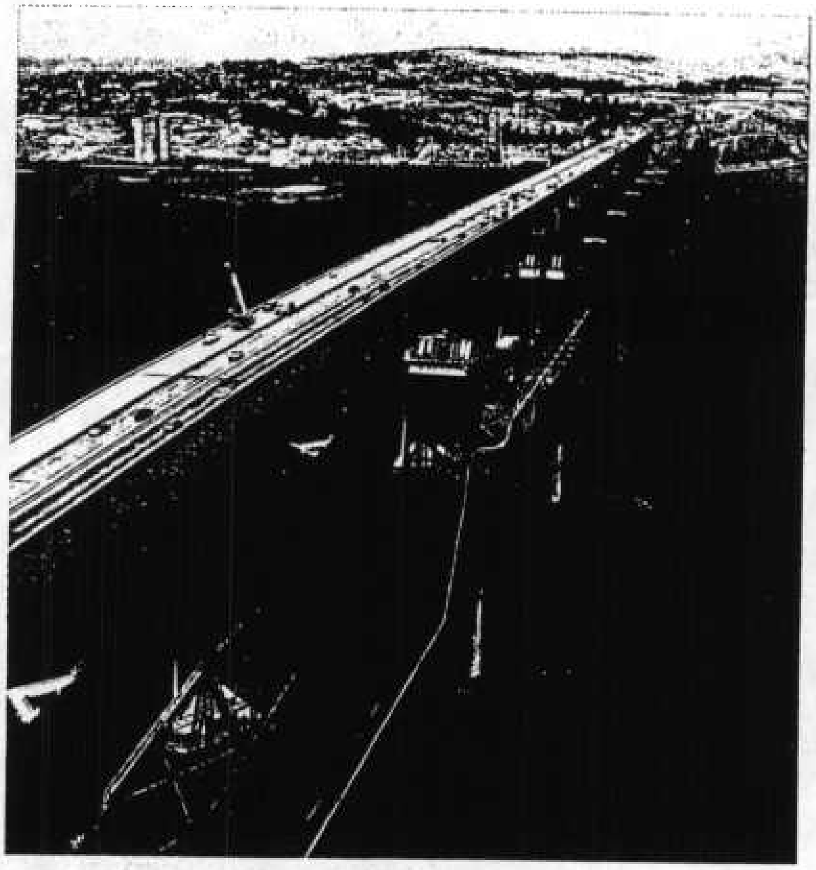
Why Use Structural Lightweight Concrete (SLC) In Bridge Construction?

1 Lower Weight

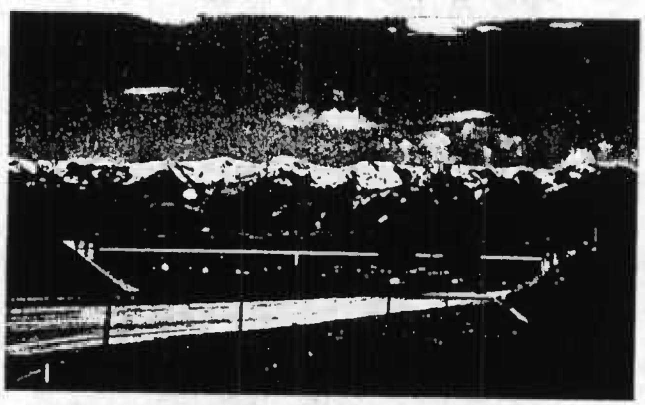
- ▲ Structural Lightweight Concrete is typically 25% to 30% lighter.
- ▲ Requires less reinforcing, prestressing and structural steel.
- ▲ Increases live load capacity.
- ▲ Permits longer spans.
- ▲ Permits deeper sections while maintaining the same dead load.
- ▲ Allows for bridge up-grades and expansion without replacing or adding support foundations.

2 High Durability

- ■ Low permeability.
- ■ High freeze/thaw resistance.
- ■ Good resistance to deicing salts and chemicals.
- ■ The close elastic compatibility between the aggregate and matrix reduces internal stresses and minimizes microcracking.
- ■ Superior bond between the aggregate and matrix.
- ■ Non-polishing and a higher skid resistant surface improves roadway safety.

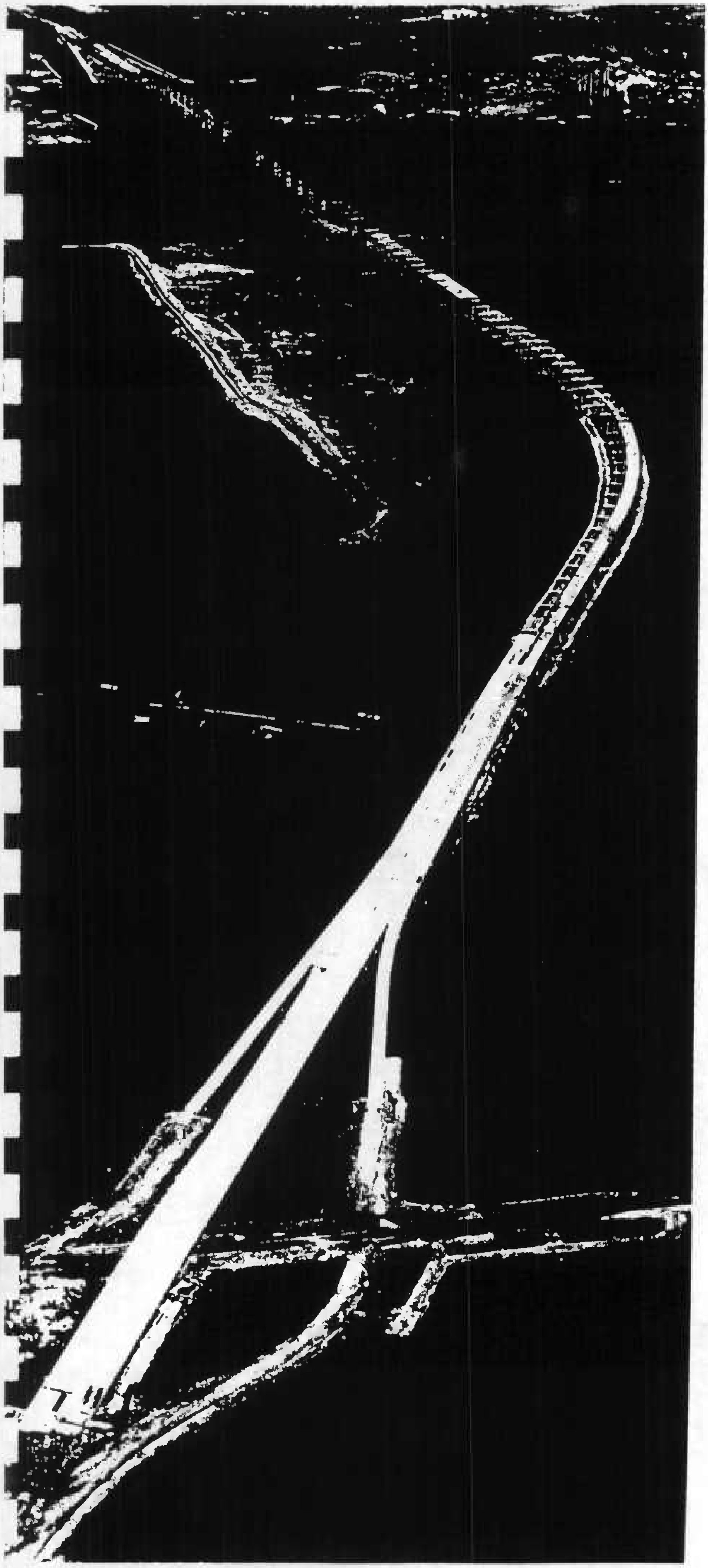


▲ **Martinez-Benicia Bridge**
Martinez, California
SLC used in deck.
Deck widened from four to six lanes.
Engineer:
Cal Trans



▲ **Silver Creek Overpass**
Over I-80, Summit County, Utah
Completed in 1968.
Bridge Length:
191 feet, 9 inches
Maximum Span:
99 feet, 9 inches
Bridge Width:
44 feet
Engineer:
Utah Department of Transportation Structures Division

Cooper River Bridge ▶
Charleston, South Carolina
Under construction in 1991.
Bridge Length:
16,450 feet
Bridge Width:
93 feet, 3 inches
Engineer:
Howard-Needles-Tammen & Bergendoff



The Test of Time

For more than 70 years structural lightweight aggregate concrete (SLC) has solved the weight and durability problems associated with exposed structures. This concrete, made with rotary kiln expanded shale, clay or slate (ESCS) lightweight aggregate, has a proven performance history in bridges. Examinations of mature bridge deck concrete has confirmed that, in terms of durability, structural lightweight concrete performs equal to or better than normal weight concrete.

In the study "Criteria For Designing Lightweight Concrete Bridges" (August 1985) the Federal Highway Administration reports that evidence was produced during visits to 30 bridges, and in contacts with state and industry representatives, that good lightweight concrete has equal or better durability than some normal weight concrete.

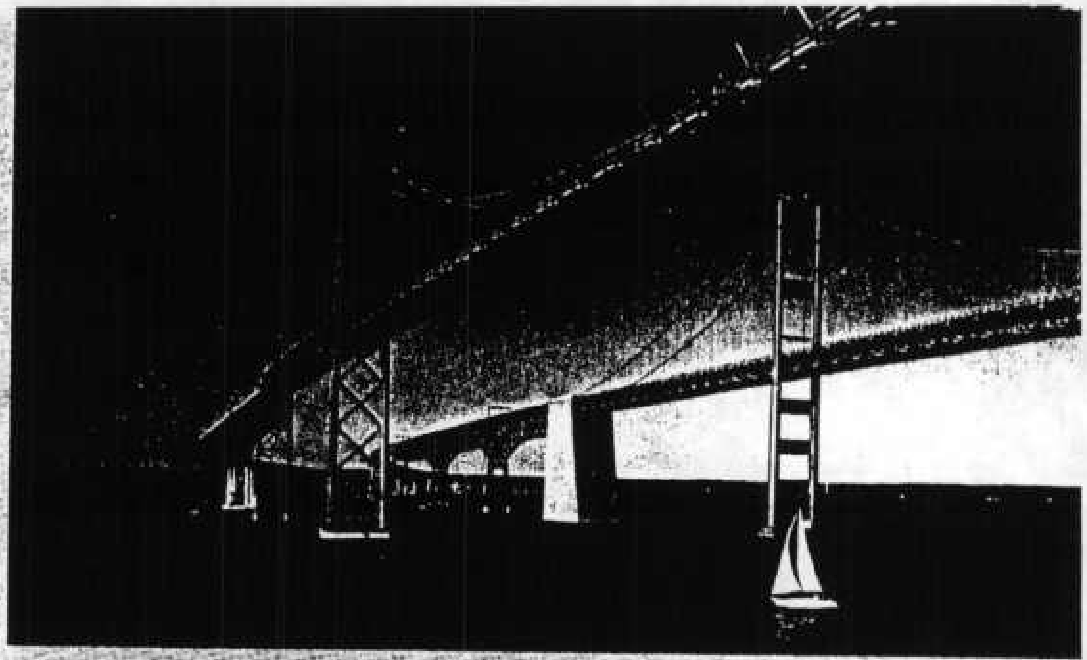
A separate independent laboratory study concluded after an examination of the Chesapeake Bay Bridge in 1975 that "concrete containing porous lightweight aggregate is less susceptible to deterioration from freezing and thawing" than normal weight concrete.

A survey of Japanese bridges in service for up to 20 years revealed that cracking, carbonation and salt penetration was reduced with structural lightweight concrete bridges, and SLC provided high degrees of durability that surpassed normal weight concrete. Also, investigations of a number of marine environment SLC structures in service for over 70 years verify laboratory results indicating good weathering resistance.

Why Use Structural Lightweight Concrete (SLC) In Bridge Construction?

3 Low Cost

- ◆ Provides versatility for renovation/retrofitting. Decks can be widened or replaced without altering existing support system.
- ◆ Reduced cost of transportation and erection are realized with precast members. More precast members can be transported per truck and less crane capacity is required.
- ◆ Lower foundation costs result from reduced size and/or number of supports.
- ◆ Lower construction costs result from reduced need for extensive falsework/formwork, less reinforcing steel, and smaller structural members.
- ◆ Greater design flexibility to meet today's challenges of design and construction.
- ◆ High compressive strengths capable of meeting modern engineering requirements.



Boknasundet Bridge ▶
Rogaland County, Norway
Bridge Type: Balanced cantilever box girder.
Bridge Length: 1270 feet, 6 inches (385 meters)
Maximum Span: 627 feet (190 meters)
Bridge Width: 36 feet, 4 inches (11 meters)
Engineer: Bridge Department, Director of Public Works

Ohio Turnpike Twin Bridges
Maumee River, Toledo, Ohio
Deck replacement and widening.
Bridge Length: 1384 feet
Maximum Span: 176 feet, 6 inches (longest)
11 spans (composite with post-tensioned SLC).
Engineer: J. E. Greiner Company

Coronado Bridge ▶

San Diego, California

307 precast-prestressed SLC girders were used.

Bridge Length: 11,179 feet

Bridge Height: 50 to 200 feet

Maximum Girder Length: 151 feet

Engineer:
State of California
Department of Public Works,
Division of Bay Toll Crossings
E. R. Foley, Chief Engineer

Heart Of America Bridge

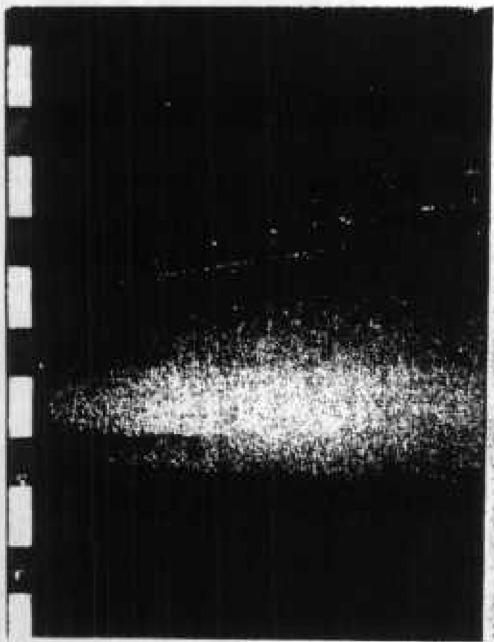
Kansas City, Missouri

Completed in 1985.

Composite deck,
SLC cast-in-place topping over precast SLC panels.

Maximum Span:
440 feet

Engineer:
Howard-Needles-Tammen & Bergendoff ▼



▲

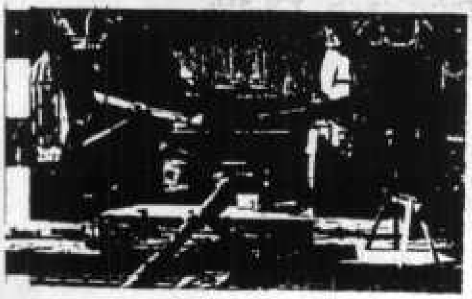
William Preston Lane Bridge

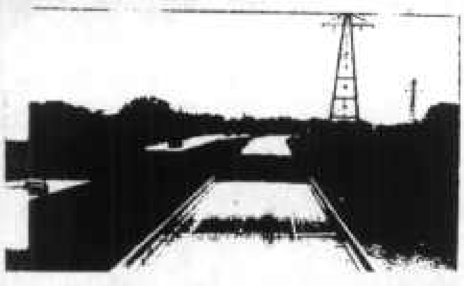
Over Chesapeake Bay at Annapolis, Maryland

Deck replacement.

Engineer: Greiner Engineering

Note: SLC bridge decks constructed in 1952 demonstrated superior performance when compared to companion heavyweight concrete decks; therefore, SLC bridge decks were chosen by the owners and engineers for the parallel span opened in 1975.





▲

Woodrow Wilson Memorial Bridge

Washington, DC

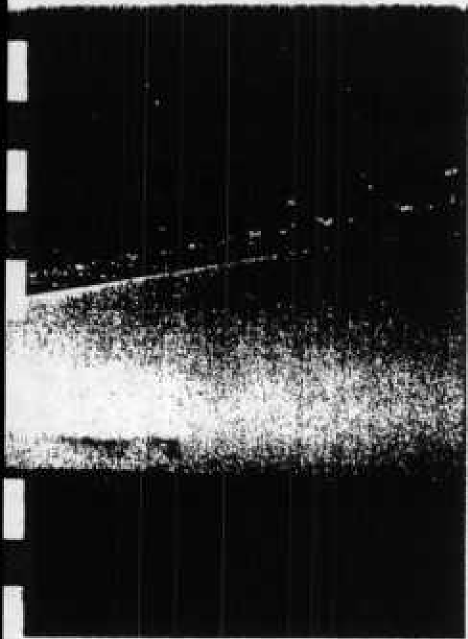
Completed in 1983.

Deck replacement and widening from 89 feet to 93 feet, 2.5 inches.

Deck Panels Specifications:
1026 SLC post-tensioned panels,
46 feet, 7.25 inches x 12 feet x 8 inches.

28 Day Strength:
5000 psi specified,
6640 psi average test result.

Engineer:
Greiner Engineering



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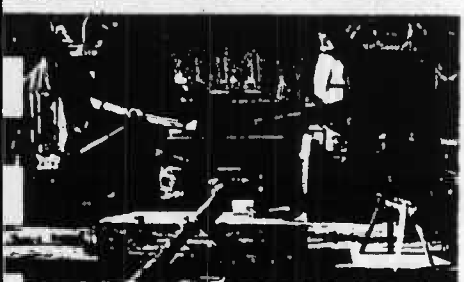
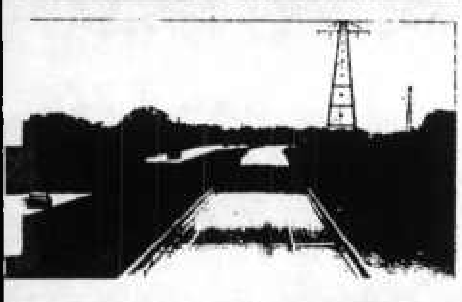
Note: SLC bridge decks constructed in 1952 demonstrated superior performance when compared to companion heavyweight concrete decks; therefore, SLC bridge decks were chosen by the owners and engineers for the parallel span opened in 1975.





Why So Durable?

Freeze-thaw durability in any type of concrete (normal weight or lightweight) is achieved by using durable aggregates encased in a durable cement mortar. Although expanded shale, clay and slate (ESCS) aggregates are absorptive, they are also very durable, being composed of vitrified silicates. Laboratory tests showing high Durability Factors after 300 cycles of freeze-thaw exposure are normal for structural lightweight aggregate concrete. So it is no surprise that properly proportioned air entrained SLC made with ESCS lightweight aggregate is quite durable.

In addition to being durable, ESCS aggregates have other unique properties that lead to increased durability. These properties include better elastic compatibility, internal curing and improved bond between the lightweight aggregate and the cement paste.

ESCS aggregates are less rigid than normal weight aggregates. However, their stiffness closely matches that of the air entrained cement paste used in bridge deck concrete. Studies show that this elastic compatibility results in significantly lower stress concentrations at the aggregate-paste interface, thus greatly reducing the tendency for microcracking.

The contact zone is the microscopic transition layer connecting the coarse aggregate particle and the enveloping cement mortar. The quality of this interface is a decisive factor in the long-term durability of concrete. Several studies have shown that the contact zone in lightweight aggregate concrete is far superior to that of normal weight concrete. Specific studies on the morphology and distribution of chemical elements at the aggregate/paste interface conclude the following:

1. Expanded shale lightweight aggregates are extremely well bonded to the mortar matrix and this bond far exceeds the normal weight bond.

2. Cracking and local areas of high calcium content are often observed in the contact zone with normal weight concrete. In contrast, silica content is higher in the contact zone with SLC than in the cement paste in general.

Prestressed, Precast And Cast-In-Place

Structural Lightweight Concrete is ideal for all types of bridge construction. The lower self weight makes it economical to transport sizeable precast sections, reduces the need for extensive falsework, speeds erection, and allows for the use of smaller, more economical equipment.

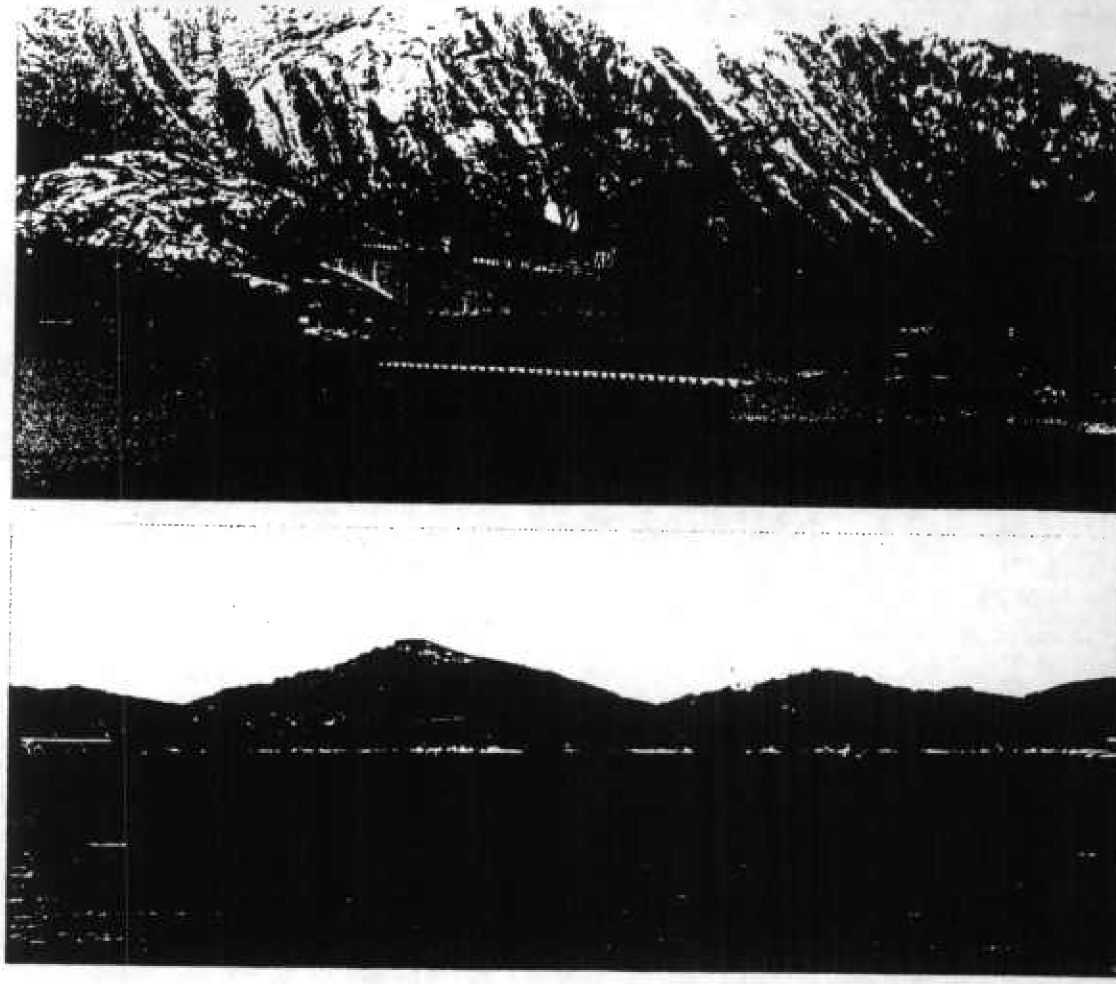
The overall weight reduction with SLC affords designers greater design latitudes to meet today's challenges of terrain, budget, seismic conditions and construction schedules. Reduced weight allows less reinforcing and structural steel, less seismic bracing, smaller foundations and longer spans. The result is a substantial cost savings.

Structural lightweight concrete also allows the deck thickness to be increased without increasing overall weight, as compared to normal weight concrete. This affords increased stiffness and additional cover for reinforcing, thereby improving durability.

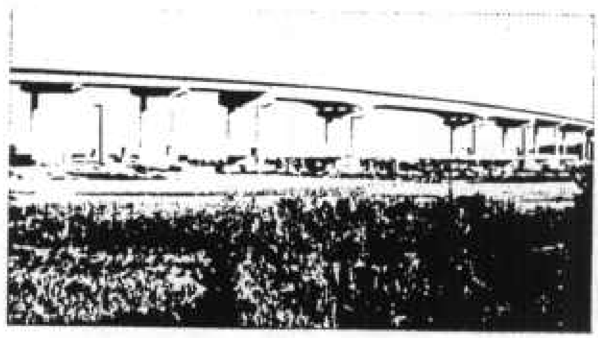
Why Use Structural Lightweight Concrete (SLC) in Bridge Construction?

4 Excellent Performance Record

- *Structural Lightweight Concrete has a proven performance record of successful use in severely exposed marine and bridge construction for more than 70 years. Over this period it has been subjected to extreme weather and loading conditions, and has proven sound and durable.*



Sandhornøya Bridge
Gildeskål, Nordland County, Norway
Bridge Type: Balanced cantilever box girder.
Total Length: 1234 feet, 2.4 inches (374 meters)
Maximum Span: 508 feet, 2.4 inches (154 meters)
Bridge Width: 25 feet, 9 inches (7.8 meters)
Engineer: A. Aas Jakobsen, Oslo



Sabestian Inlet Bridge
Vero Beach, Florida
Completed in 1964.
1991 review showed deck to be in good condition.
Precast and pretensioned girder system.
Cast-in-place deck.
Bridge Length: 380 feet
Maximum Span: 180 feet

Antioch Bridge
Antioch, California
Completed in 1977.
2 lane lightweight deck placed by pump.
Bridge Type: Prestressed concrete multiple box.

Lewiston Pump-Generating Plant Bridge

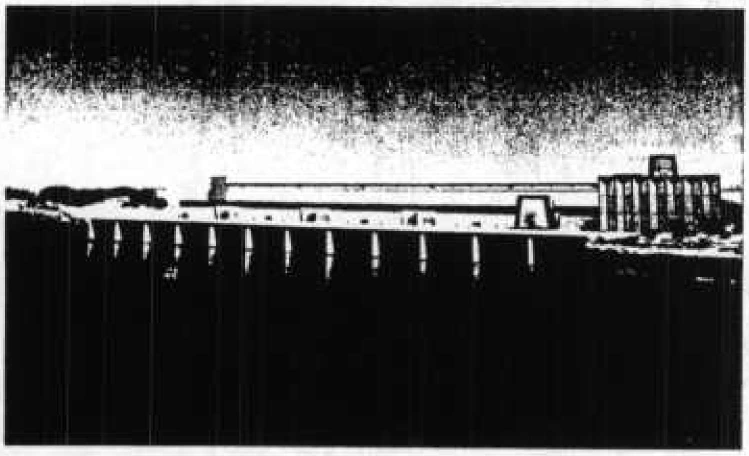
Lewiston, New York

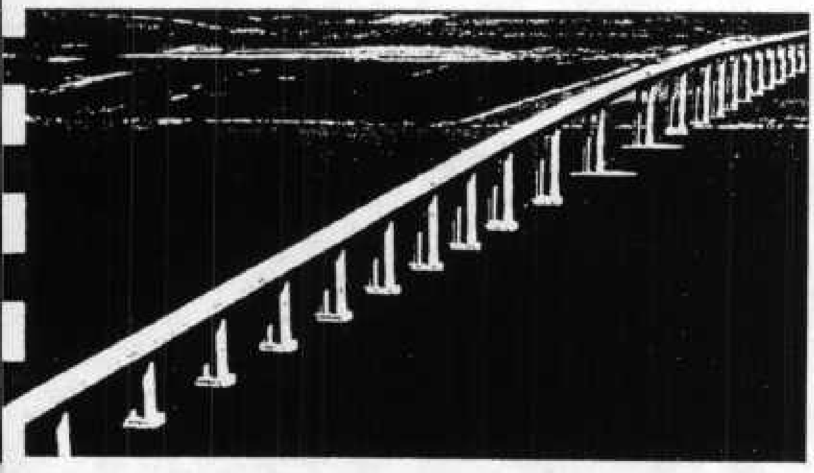
204 prestressed SLC girders of 68 feet each.

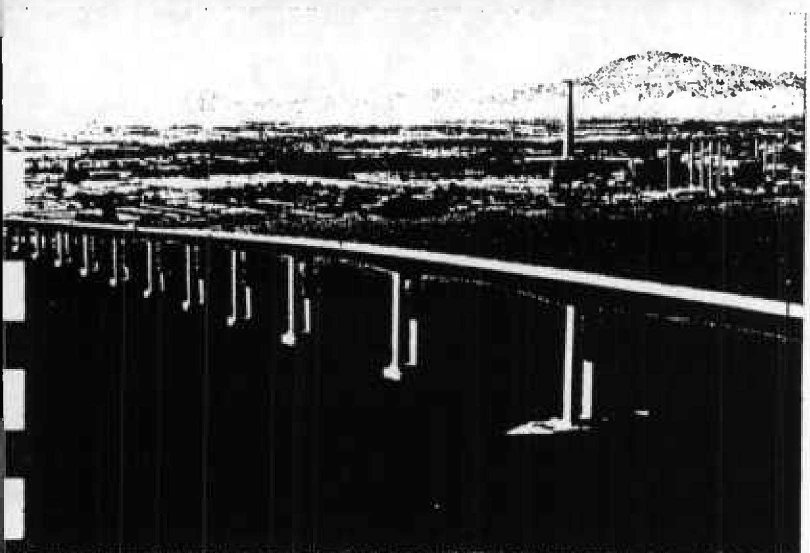
6000 precast SLC roadway slabs (4000 psi), 3 inches thick (7 feet x 2 feet each).

24 special walkway girders ("U" shaped, 6 feet wide and 4 feet deep).

Engineer:
Uhl, Hall & Rich







Renovation & Repair

In 1990 more than one-half million bridges in the United States alone were classified as "deficient" in terms of structural integrity or traffic capacity. This staggering need for renovation, repair or replacement can be largely addressed with the use of Structural Lightweight Concrete.

One of the most extensive applications of SLC can be seen in bridge re-decking. SLC decking achieves two significant goals: low deadload and high durability. The combination of these two factors often means that bridge widths, traffic lanes, and the thickness of structural slabs can be increased while utilizing existing piers, footings and other structural members. Depending on the nature of the renovation, the use of SLC often increases the live load capacity for older bridge structures, thus meeting the current load specifications.

The use of SLC in bridge structures constitutes a powerful renovation tool. This lighter, more durable material helps designers by providing solutions for bridge structures that adequately address both expansion and economic issues.

For more information on the advantages of lightweight concrete made with expanded shale, clay and slate, contact your local supplier of Rotary Kiln Expanded Shale, Clay or Slate lightweight aggregate.

Wherever you live, work or play, ESCS improves your world!

For nearly a century ESCS (Expanded Shale, Clay and Slate) has been used successfully around the world in more than 50 different types of applications. The most notable among these are concrete masonry, high-rise buildings, concrete bridge decks, precast and prestressed concrete elements, asphalt road surfaces, soil conditioner and geotechnical fills.

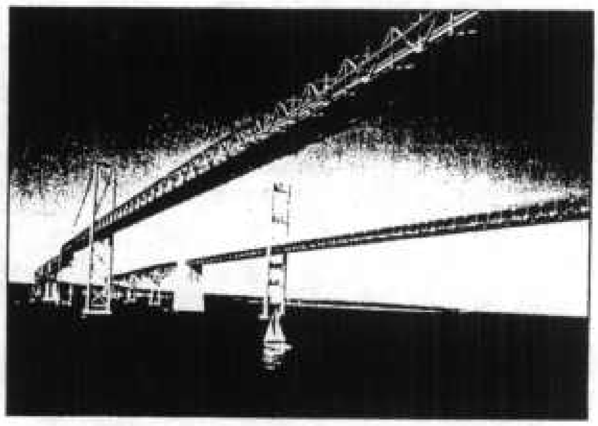
What is ESCS? It is a unique, ceramic lightweight aggregate prepared by expanding select minerals in a rotary kiln at temperatures over 1000°C. The production and raw material selection processes are strictly controlled to insure a uniform, high quality product that is structurally strong, stable, durable and inert, yet also lightweight and insulative. ESCS gives designers greater flexibility in creating solutions to meet the challenges of dead load, terrain, seismic conditions, construction schedules and budgets in today's marketplace.

High Performance Concrete Masonry

ESCS concrete masonry units are up to 40% lighter than traditional masonry units. This lighter weight results in increased mason productivity, lower construction costs and reduced injuries. ESCS masonry also provides superior insulation by combining high R-values with thermal mass and low thermal bridging. In addition, it offers superior fire resistance, effective sound absorption, excellent seismic performance, low shrinkage and high strain capacity.

Asphalt Pavement

When bonded to asphalt, ESCS creates an advanced road surface that is safer, more economical and longer lasting than conventional aggregates. Wet or dry, road surfaces of ESCS aggregate provide superior skid resistance that is maintained throughout the surface life, because ESCS does not polish as it wears. Because it's lightweight, ESCS affords shipping and handling cost advantages to the contractor. Also, damage to windshields, headlights, and paint caused by "flying" stones is virtually eliminated with ESCS, thus avoiding costly insurance claims and motorist complaints.



Structural Concrete

ESCS structural lightweight concrete solves weight and durability problems in buildings and exposed structures. ESCS concrete has strengths comparable to normalweight concrete, yet is typically 25% to 35% lighter. ESCS offers design flexibility and substantial cost savings by providing less dead load, improved seismic

(Continued on back page)

A World of Uses

High Performance Concrete Masonry

1m. Standard concrete masonry units (CMU's) above & below grade
2m. Architectural units (split face, colored, etc.)
3m. Larger CMU's (8"x8"x24", etc.)
4m. Prison construction
5m. Concrete brick (all shapes & colors)
6m. Segmental retaining walls
7m. Privacy fences & sound barrier walls
8m. Sound absorption walls
9m. Other (pre-cast lintels, loose fill core insulation, pavers, patio units, etc.)

Asphalt Pavement (rural, city & freeway)

1a. Surface treatments (chip seal, seal coat, etc.)
2a. Plant mix seal overlay & open-graded friction coarse
3a. Hot mix surface coarse
4a. Micro-surfacing (slurry seal)
5a. Cold mix (pothole patch, minor repairs, etc.)

Structural Concrete (including high performance)

1s. Floors in steel frame buildings (fill on metal deck)
2s. Precast & prestressed elements (beams, double-tees, tilt-up walls, raised access floor panels, planks, hog slats, utility vaults, pipes, bridge decks, ornamentals, etc.)
3s. Concrete frame buildings & parking structures (all types, including post-tensioned floor systems)
4s. Floating docks, boats & offshore oil platforms
5s. Bridge decks, piers & AASHTO girders (prestressed, post-tensioned & normal reinforcement)
6s. Thin shell roof structures
7s. Topping over precast concrete

Geotechnical

1g. Waterfront structures
2g. Landscape & elevated plaza fills
3g. Bulkheads & retaining walls
4g. Structural repairs & rehabilitation
5g. Fill over poor soil & marshlands
6g. Insulating backfill & insulating road base
7g. Shallow foundations
8g. Enveloping underground conduits & pipelines for insulation or when in unstable soil conditions
9g. Landfill leachate drainage systems

Horticulture

1h. Soil conditioner (planting, golf greens, potting soil, etc.)
2h. Soil conditioner for dirt tracks (running, bike, horse, stock car) & baseball infields, etc.
3h. Ground cover (decorative & insulating)
4h. Herbicide & fertilizer carrier
5h. Hydroponics

Specialty Concrete

1sc. Topping on wood floor systems
2sc. Roof fill for flat roofs (insulation & slope)
3sc. Insulating fill around temperature sensitive elements
4sc. Bagged concrete mix
5sc. Cement wallboard
6sc. Artificial stone
7sc. Refractory (fireplace logs & boxes, chimney liners, etc.)
8sc. Insulating refractory for industrial uses in kilns, boilers, stacks, petrochemical refining, etc.
9sc. Ferrocement & shotcrete
10sc. Animal & environmental structures (sewage treatment, etc.)
11sc. Lightweight concrete roof tiles

Miscellaneous

1x. Grog for clay brick
2x. Coverstone & ballast on built-up roofs
3x. De-slicking/traction grit for icy roads
4x. Medium in wastewater treatment & water filters
5x. Fire protection for impermeable plastic liners

Please send additional information.
Circle specific uses listed in the brochure.

- **Concrete Masonry**
  1m 2m 3m 4m 5m 6m 7m 8m 9m
- **Asphalt Pavement**
  1a 2a 3a 4a 5a
- **Structural Concrete**
  1s 2s 3s 4s 5s 6s 7s
- **Geotechnical**
  1g 2g 3g 4g 5g 6g 7g 8g 9g
- **Horticulture**
  1h 2h 3h 4h 5h
- **Specialty Concrete**
  1sc 2sc 3sc 4sc 5sc 6sc 7sc 8sc 9sc 10sc 11sc
- **Miscellaneous**
  1x 2x 3x 4x 5x
- **ESCSI Literature List**

Name:____________________

Company:____________________

Address:____________________

State:__________ Zip:__________

Telephone:(______)________________

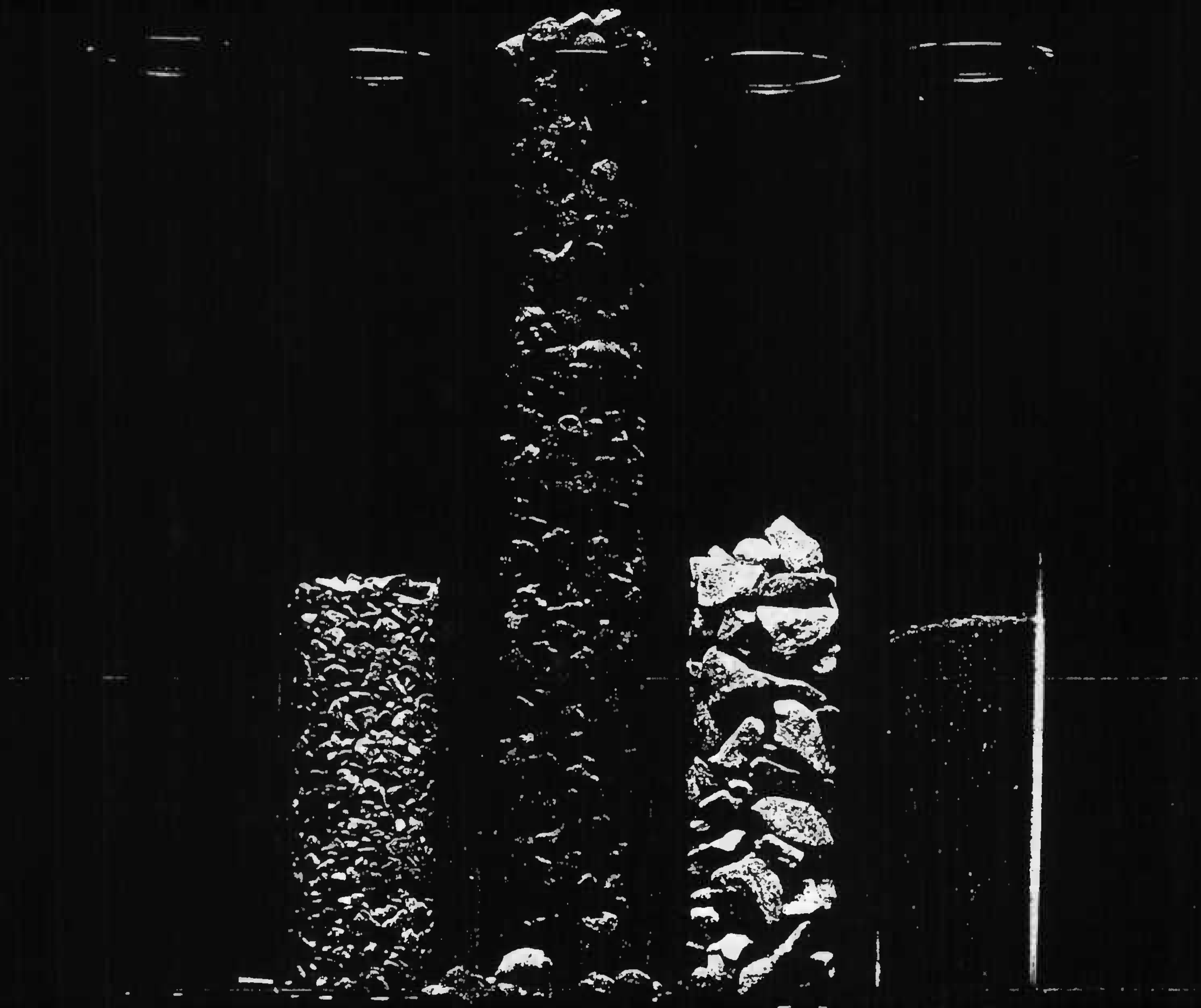
Comment? ____________________

For easy reference, add these cards to your files. See reverse side for manufacturer's name, address, and telephone number.

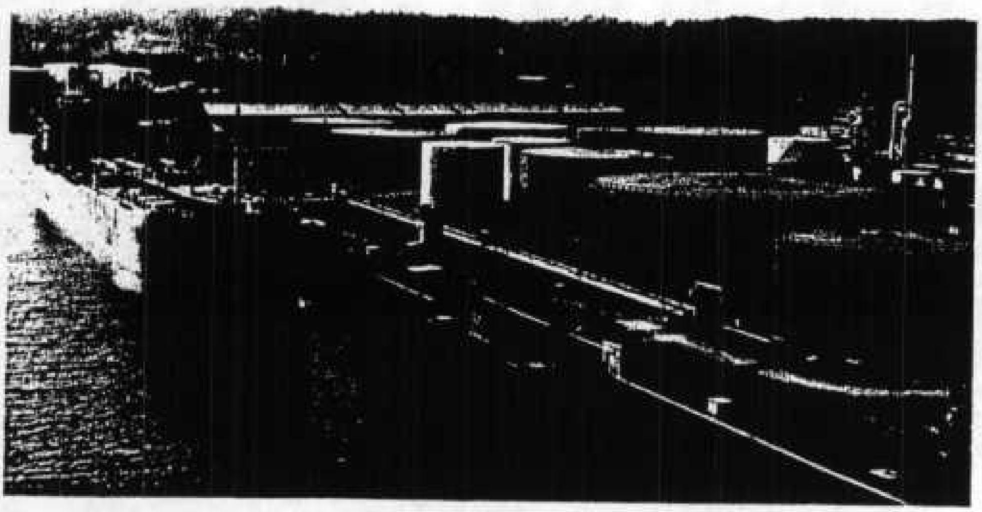
HIGH PERFORMANCE
EXPANDED
SHALE, CLAY & SLATE
LIGHTWEIGHT AGGREGATE

HIGH PERFORMANCE
EXPANDED
SHALE, CLAY & SLATE
LIGHTWEIGHT AGGREGATE

Rotary Kiln Produced
Lightweight Aggregate
For Geotechnical Applications



1 lb. Soil | 1 lb. Gravel | **1 lb. ESCS Lightweight Aggregate** | 1 lb. Limestone | 1 lb. Sand

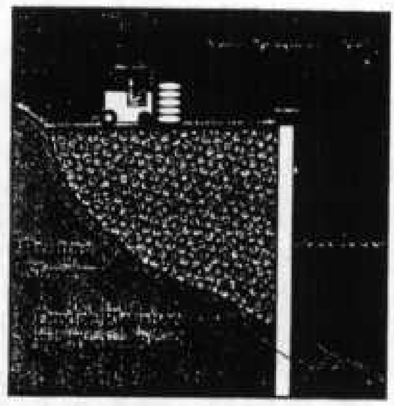


Port of Albany Marine Terminal Expansion ❖ *Albany, New York*
Engineer: Childs Engineering, Inc., Medfield, Mass.

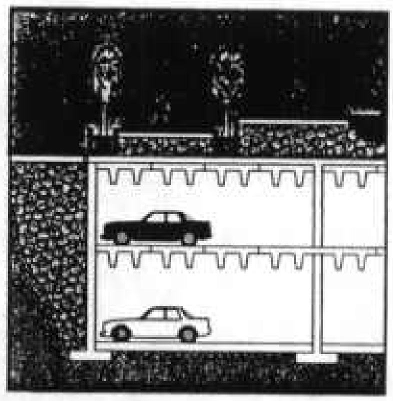
Modifications to the Port Albany Marine Terminal reclaimed an area of approximately 1500' x 80' in an unstable slope area and provided increased dockside draft to permit service by large oil tankers. LWA backfill minimized lateral earth pressures, while also reducing overburden pressures on the sensitive silts. Transportation, placement and compaction of the LWA soil fill was readily accomplished in a minimum time frame and without logistic difficulties. Peak delivery rates were 1300 tons, approximately 55 truck-loads per day.

Retaining Wall Backfill ❖ *Providence Rhode Island*
Engineer: C.E. Maguire Engineers, Mansfield, Mass.

This project involved the construction of a retaining wall behind the Rhode Island State House at the Providence River. The weight of the entire project, including the wall, the backfill, and a future roadway at the top of the wall, was quite significant. With the area's soft clay strata, there were engineering concerns that too much weight might force the existing bulkhead toward the river. The use of approximately 3,500 cubic yards of LWA fill reduced the total project weight so dramatically that the probability of deep seated bulkhead failure was virtually eliminated.

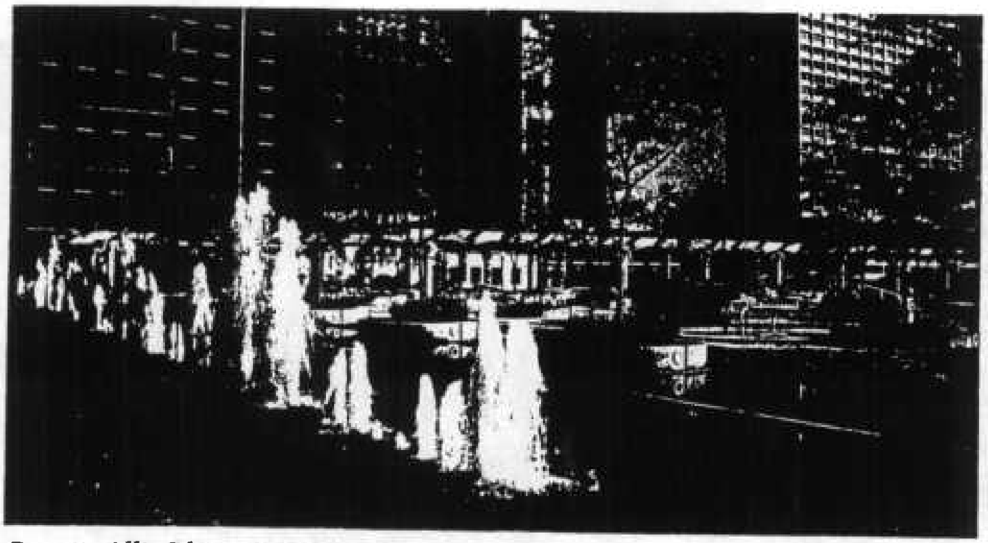


Waterfront Structures
- ❖ Allows economical modification to marine terminals
- ❖ Allows increased dockside draft
- ❖ Reduces lateral thrust/bending moments
- ❖ Allows free drainage and control of in-place density



Landscape & Plaza Fills
- ❖ Minimizes dead loads
- ❖ Free draining helps minimize hydrostatic potential
- ❖ More planters and levels can be added
- ❖ Easy to transport and install

Bulkheads & Retaining Walls
- ❖ Reduces soil thrust as well as bending moments
- ❖ Reduces forces against abutment and end slope
- ❖ Allows free drainage
- ❖ Improves embankment stability

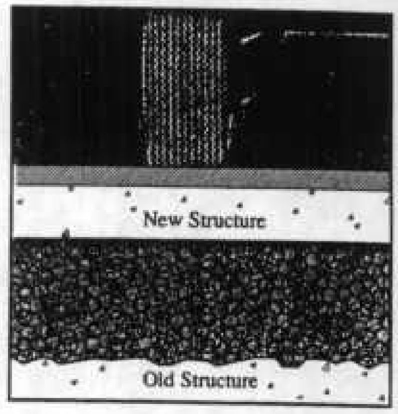


Barney Allis Plaza ❖ *Kansas City, Missouri*
Architect/Engineer: Marshall & Brown Incorporated

6000 cubic yards of LWA (expanded shale) was used as loose granular fill on top of an existing underground parking garage. The material provided subsurface drainage, weight reduction and long term stability. In addition, the LWA material established the grade and contour for a plaza area which was built on top of the parking structure. The LWA material was graded ASTM C330 3/4" x No. 4.

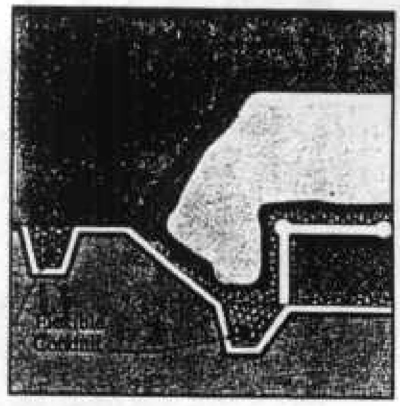
Calgary Pipeline ❖ *Calgary, Canada*
Engineers: City of Calgary / Pildysh & Associates Consultants, Ltd.

Watermains must be installed below the level of frost penetration. In Calgary this requires deep, wide trenches. Such trenches are expensive and often dangerous to workers. The insulating properties of LWA fill allowed engineers to reduce trench depth from 3.3 meters to 2.1 meters. This provided safer working conditions and reliable freeze protection with an environmentally "friendly" material. LWA backfill will also afford easier winter excavation for pipe repair, reduce disruption of water supply and street traffic by decreasing construction time, and eliminate the need for synthetic insulating board and wide trenches. With LWA backfill, present and future savings in capital costs alone are expected to be in the millions.



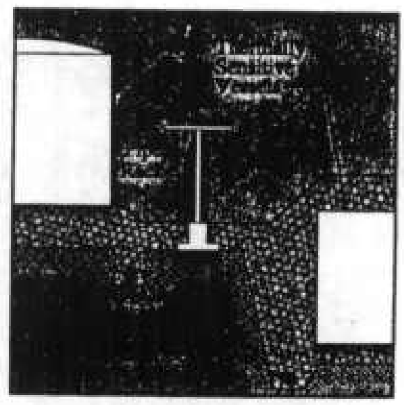
Structure Repair & Rehabilitation

❖ Reduces dead load on existing structures
❖ Easy transportation and installation increase productivity
❖ Precise gradations allow for a uniform and controlled in-place density



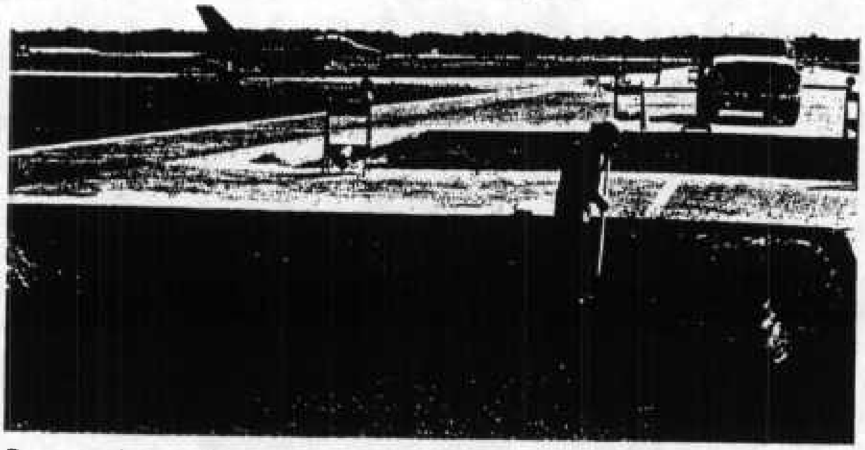
Landfill Drainage

❖ Inert; high chemical stability
❖ Reduces deadloads on pipes
❖ Allows free drainage of leachate/water
❖ Acid insoluable



Insulating Backfill

❖ Substantially reduces ground movement-induced stresses on buried pipes and structures
❖ Counteracts frost heaving, resists freeze/thaw cycles and highly insulative
❖ Inert, non-corrosive and stable

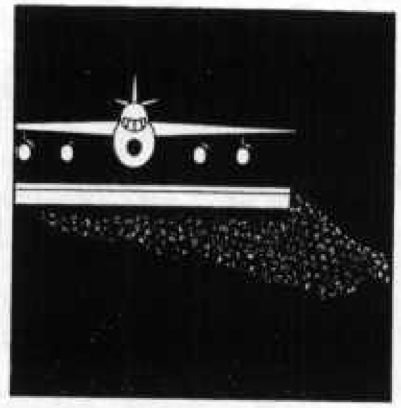


Runway Repair ❖ *Norfolk Naval Air Station* ❖ *Norfolk, Virginia*
Engineer: Patton, Harris, Rust & Associates

Much of this facility was built on marsh land. Poor soil conditions and intense traffic loads produced differential settlements and "alligator" cracking of the taxiway after only 3 years. High soil stability and relief from overburden pressures were provided by substituting compacted LWA for heavy, unstable soil to a depth of 4 feet. LWA material was placed at 6 inch lifts and hand compacted with a vibratory plate. Field compaction and projected yields were monitored using a nuclear densometer. The compacted base was then paved and air traffic restored in a timely manner. Differential settlement was economically solved.

Embankment Fill ❖ *Louisiana DOT D Test Project* ❖ *Morgan City, Louisiana*

Highway embankment fills over unstable soils present particularly difficult problems. Uneven settlement can produce a "Roller Coaster" ride, as well as significant maintenance problems. The Louisiana Department of Transportation and Development constructed a series of roadway test sections with sand fill 9.5 ft. in depth. In one section, 2.5 ft. of sand was replaced with 2.5 ft. of LWA fill. The reduction in weight, coupled with the increase in long term stability provided by the LWA's high angle of internal friction, reduced settlement 40% to 60% as compared to the all-sand fill. Considerable savings in highway maintenance, repairs and replacement can be realized if differential settlement is reduced.



Fills Over Poor Soils & Marsh Lands

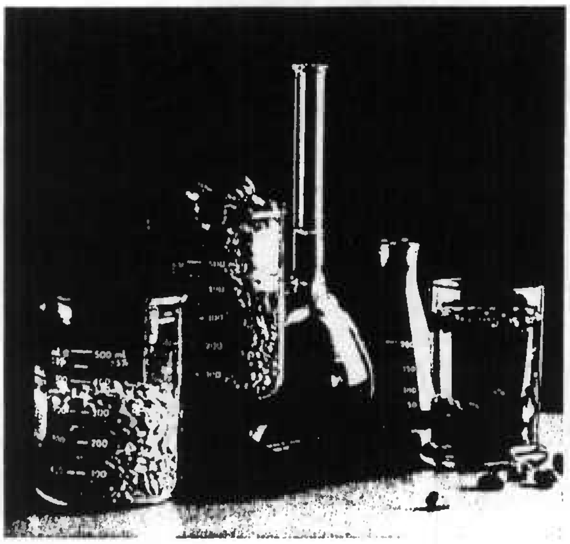
❖ Allows otherwise unuseable land to be reclaimed and developed
❖ Design elevations are achieved with low fill weight
❖ Low fill weight increases slope stability
❖ Controlled gradations assure uniform and consistent in-place density
❖ Long-term settlement is controlled and reduced
❖ Controlled fill allows uniform load distribution

Underground Conduits & Pipelines

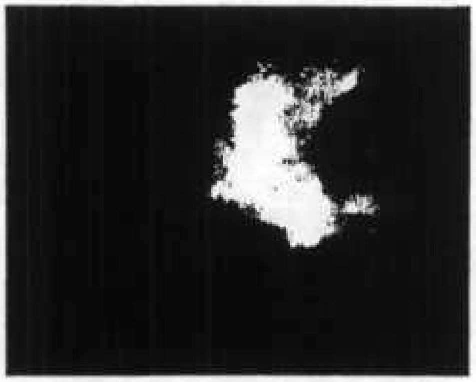
❖ Reduces dead loads on buried structures
❖ Allows construction of higher fills
❖ Minimizes hydrostatic potential
❖ Provides thermal insulation to underground facilities
❖ Economic alternative to flowable fills

Contact a Rotary Kiln Expanded Lightweight Aggregate producer listed on the back of this brochure for complete information and specifications.

THE PROVEN SOLUTION

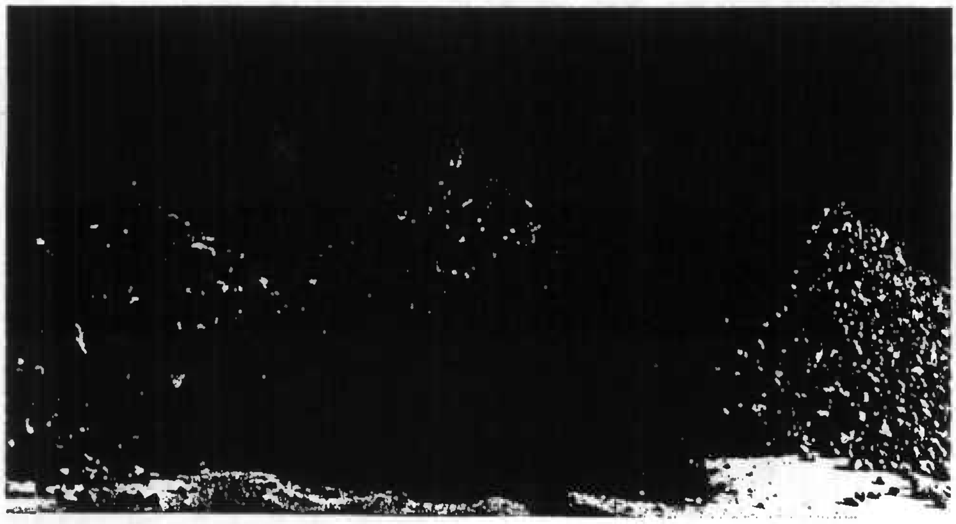


For almost 50 years Rotary Kiln produced Expanded Lightweight Aggregate (LWA) has been effectively used to solve geotechnical engineering problems and to convert unstable soil into usable land. Lightweight aggregate can reduce the weight of compacted geotechnical fills by up to one-half. Where thermal stability is required, LWA provides significantly greater thermal resistance when compared to soil, sand or gravel fill. It affords permanent economical insulation around water lines, steam lines and any other thermally sensitive vessel. This inert, durable, stable, free-draining and environmentally "friendly" lightweight aggregate is extremely easy to handle and provides economical long term solutions for geotechnical challenges.



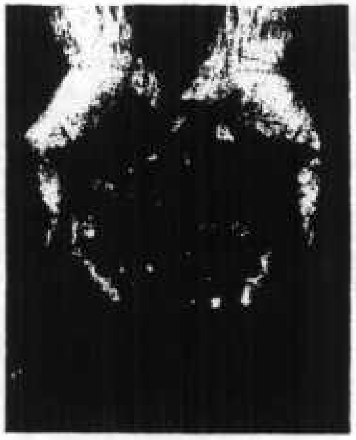
THE MATERIAL

Expanded shale, clay and slate lightweight aggregate (LWA) has a long track record of quality and performance. Since its development in the early nineteen hundreds, LWA produced by the rotary kiln process has been used extensively in asphalt road surfaces, concrete bridge decks, high-rise buildings, concrete precast/prestressed elements, concrete masonry and geotechnical applications. The quality of LWA results from a carefully controlled manufacturing process. In a rotary kiln, selectively mined shale, clay or slate is fired in excess of 2000° F. The LWA material is then processed to precise gradations. The result is a high quality, lightweight aggregate that is inert, durable, tough, stable, highly insulative, and free draining, ready to meet stringent structural specifications.



DESIGN ADVANTAGES

- Reduces Dead Loads
- Reduces Lateral Forces
- Reduces Over Turning Forces
- Provides High-Friction Angle
- Controlled Gradations
- Free Draining
- Water Insoluable
- Acid Insoluable
- High Insulation Value
- Chemically Inert
- High Strength & Durability
- Easy to Handle and Install
- Readily Available
- Environmentally "Friendly"



PHYSICAL PROPERTIES

The physical properties for specific types of rotary kiln expanded light-weight aggregate may vary according to manufacturer. For precise information on unit weight, specific gravity, compacted density, friction angle, thermal conductivity and the other physical properties of a particular LWA material, consult the rotary kiln expanded shale, clay or slate producers listed on the back of this brochure.

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Jeffrey B. Otto
411 S. Ivy Lane
Glen Mills, PA 19342
(610) 358-9366

Education

Master of Science in Environmental Engineering
Master of Science in Engineering Management, 1993;
Drexel University, Philadelphia, PA

Bachelor of Science in Mechanical Engineering, 1984;
Widener University, Chester, PA

Bachelor of Science in Agricultural Engineering, 1979;
University of Delaware, Newark, DE

Professional Registration

Registered Professional Engineer (Mechanical)- PA

Areas of Expertise

Strategic Planning, Project Assessment and Economic Development
Contract Negotiations
Energy Plant Design and Systems Energy Utilization
Utility Restructuring and Deregulation
Wholesale and Retail Electric, Gas and Thermal Energy Rates
Public Relations & Sales

Experience

E Solutions - Owner (1997 - present)

Consulting engineering firm that provides energy project development; economic analysis of energy procurement options and environmental assessment services.

Recent clients include: Enron Corporation; Consolidated Edison of New York; PECO Energy; and Laclede Steel.

VISY Paper (NY), Inc. - Commercial Manager (1995 to 1997)

Commercial Manager for a $180 million recycling paper mill constructed on Staten Island, NY that manufactures packaging paper from 100% waste paper. Responsibilities included all environmental issues; utility services and energy systems, contract negotiations and purchasing, business development and public relations during the site selection; development and construction phases of the project.

Hired the environmental, engineering, and construction management firms; provided oversight and input into the project environmental assessment statement; secured all construction and operational permits; and implemented the first voluntary cleanup of a brown field site in New York State.

Performed negotiations for: the site purchase; over $100 million in equipment and labor contracts from international suppliers and union trade contractors; the $12 million per annum electric and natural gas supply contracts with Con Edison; a twenty year agreement with the NYC Department of Sanitation for waste paper supply and use of their marine transfer stations to transport by barge the waste paper to the Visy facility.

Managed the purchasing department and the execution and administration of all contractual documents.

Identified, wrote and secured over $12 million in Federal and NY State grants and low interest loans for the project from programs in recycling, energy efficiency, environmental benefits from traffic congestion mitigation and advanced beneficial reuse of materials.

Project manager for the evaluation of the use of landfill gas from the New York City Fresh Kills landfill into a 50 MW cogeneration plant to be constructed to service the Visy Paper paper mill. This included overseeing firms specializing in landfills, construction and cogeneration systems to evaluate the technical and financial issues associated with landfill gas collection, recovery and processing, landfill operations and environmental compliance.

Provided technical input, coordination and oversight into the evaluation of cogeneration plant configurations using LFG and natural gas, life cycle cost models, assessing the implications of the deregulated natural gas and electric energy markets; and the use of innovative financing structures which included use of Federal, NY State and NY City tax credits, and triple tax exempt bonds.

PECO Energy Company (PECO) - 1984 to 1995

Bulk Power Sales & Industrial Economic Development (1992- 1995)
Executive Account Manager (1990 to 1992)
Energy Applications Engineer (1987 to 1989)
Lead Nuclear Quality Assurance Engineer (1984 to 1987)

Bulk Power Sales and Economic Development

Marketed wholesale electricity to utility, wholesale and municipal customers throughout the United States. Performed short-term power trading transactions and negotiated longer-term energy sales contracts.

Identified strategic business opportunities for acquisition. Created, designed and developed innovative wholesale energy products and rate structures. Performed financial feasibility analysis of trades.

Created a "within the fence" utility company franchise territory at the US Steel Fairless Works complex. This innovative structure permitted US Steel to redevelop their 3,000-acre industrial site; sell the output from their 60 MW plant to customers with competitive electric, natural gas and steam contracts/rates and provide financing arrangements. The PA Public Utility Commission approved this economic development deal.

Account Management - Managed over 100 major industrial accounts that included Lukens Steel Co., US Steel Corporation and Boeing Helicopter which generated over $100 million annual revenues to PECO; customer contact for issues related to utility services, tariffs, billings of purchased fuels, energy utilization and environmental issues. Coordinated electric and gas service installations, recommended methods to increase productivity and reduce energy costs through energy audits and economic analysis of industrial processes.

Energy Management and Applications - Consultant to industrial, commercial and residential customers on heating, ventilating and air conditioning (HVAC) systems, lighting designs and energy technologies. Performed system energy usage calculations, cost analysis, and design review for new and retrofit applications. Designed the computerized database linked to the corporate billing system to develop energy usage profiles for commercial customers; developed and implemented Conowingo Power Company's Excellence in Energy Efficiency Program designed to improve the energy efficiency of new residential structures.

Quality Assurance - Supervised the performance of fabrication and programmatic audits on material manufacturers, suppliers, and architect engineers to verify compliance with nuclear safety related requirements. Approval responsibility of procurement documents, technical and design criteria specifications, and Quality Assurance Programs for the nuclear industry. Responsible for the design and implementation of PECO's corporate tracking and trending program of nuclear findings.

Chicago Bridge & Iron Industries (CBI) *Project Engineer* (1979 to 1982)

Designed, fabricated and constructed steel plate structures for municipal, commercial, nuclear and petroleum related applications. Supervised project engineers during field modification of piping systems and containment vessels in nuclear power plants and oil refineries. Provided construction management oversight and direction to union craft labor personnel in manufacturing operations and construction projects. Performed engineering tasks such as drafting, design analysis, and material and labor estimating. Trained in manufacturing processes including scheduling, welding, heat treatment and painting techniques.

Achievements

Former Director-	Staten Island, NY Economic Development Corporation
Former Trustee -	Staten Island, NY Botanical Gardens
Former Trustee-	St. Elizabeth Ann's Health Care & Rehabilitation Center
Former Chairman -	ASHRAE National Technical Committee - Systems Energy Utilization
Former Chairman -	Planning Commission, Media Borough, PA

National Engineering Honor Society (1983 - 1984)

Resume

JOHN GREGORY LAMBERT
3202 Spring Trail Drive
Sugar Land, Texas 77479
(281) 565-5764

EXPERIENCE:

Director – Enron North America; Houston, Texas. Originator for environmental investment unit. Responsible for finding, evaluating, structuring and closing equity and subordinated debt investments in environmental related projects or firms. Successfully closed a $30 million financing for the expansion of a tissue mill that utilizes waste paper and a $60 million acquisition of a landfill gas collection and processing company. (December 1996 to March 2000)

Vice President, Project Finance – Sceptre Power Company; Santa Ana, California. Responsible for all project financings and selected project development for medium sized independent power company focusing on the international market. Successfully led all phases of the development and financing of a 151 mW combined-cycle, low-Btu gas fired power project built in Pakistan. (January 1993 to December 1996)

Vice President, Project Finance – North Canadian Power Company; Orange, California. Responsible for project financing and selected project development for prominent North American independent power company. Responsible for restructuring and closing of take out financing for $205 million New York cogeneration project. (April 1992 to December 1992)

Vice President – The Bank of California; Los Angeles, California. Responsible for financing independent power and cogeneration projects, including economic pro forma analysis, client proposals, credit approval recommendations and loan document negotiations. Successfully closed seven project financing participations and three agented transactions representing institutional exposure of more than $300 million. (April 1988 to April 1992)

Petroleum Engineer – Delta Petroleum Corporation; Tustin, California. Performed reservoir engineering and geologic mapping duties for natural gas drilling and production company with more than 175 wells in southeastern Kentucky. Also assisted with preparation of financial statements, evaluation of potential acquisitions and financial evaluation of major leveraged buyout candidate. (February 1986 to March 1988)

National Accounts Officer – The Bank of California; Los Angeles, California. Worked as a lending officer and petroleum engineer in the energy lending group of a medium-sized California bank. Performed credit analysis and petroleum reserve analysis for prospective oil and gas loans and prepared credit recommendations for senior management approval. (August 1983 to January 1986)

Project Engineer, Reservoir Group – Exxon Co, USA; Harvey, Louisiana. Performed reservoir engineering analysis for onshore Louisiana and Mississippi oil and gas fields. Successfully completed economics, well logging and reservoir engineering schools. (August 1981 to August 1983)

EDUCATION: **M.B.A., UCLA**, March 1988. Emphasis on finance and accounting. Received one of two annual cash awards given for Outstanding Field Study Project.

M.S. Civil Engineering, University of Kentucky, August 1981. Specialized in pipe flow mechanics and open channel hydraulics.

B. S. Civil Engineering, University of Kentucky, May 1980. Emphasis on engineering hydraulics.

HONORS: Licensed Professional Petroleum Engineer (California).

Edward V. Sedgewick III Memorial Award for Management Field Study (UCLA).

Beta Gamma Sigma – Business Honorary.

Chi Epsilon – Civil Engineering Honorary.

Honor Bandsman – University of Kentucky Marching Band.

HOBBIES: Basketball, tennis, weightlifting, piano, singing, songwriting.

STEVEN B. RADEL, JD

EDUCATION

Duquesne University School of Law — Pittsburgh, PA
- Juris Doctor, 1996

University of Pittsburgh
- Masters in Business Administration, 1991

Allegheny College — Meadville, PA
- Bachelor of Science, 1985

RELEVANT EXPERIENCE

Brownfield Redevelopment — 13 States, US
Excess Property Manager
- Developed company-wide strategic real estate plan involving legal counsel, technical support, real estate consultants and brokers
- Prepared future use and development plans and successfully integrated them with remediation plans for implementation
- Evaluated legal exposure and business risks and rewards of brownfield transactions
- Served as liaison between regulatory agencies, economic developers, contractors, community representatives, politicians and other stakeholders whose support is critical to successful projects

Environmental Management — 15 States, US
Environmental Manager
- Managed over thirty brownfield sites regulated under CERCLA, RCRA, and numerous state programs and issues regulated under TSCA, CWA, CAA, and OSHA
- Developed technical plans to address regulatory issues, implement site investigations and perform necessary remediation activities
- Developed a company-wide stormwater management protocol and lead its implementation
- Performed environmental audits as part of due diligence associated with acquisitions and divestitures
- Managed all aspects of PRP sites including liability, economic and technical issues evaluation and corresponding negotiations

EMPLOYMENT HISTORY

1991 – Present	Hanson Building Materials America Environmental Program Manager
1989 – 1991	Keystone Environmental Resources Technical Services Department Manager
1988 – 1989	Keystone Environmental Resources Project Manager
1987 – 1988	Keystone Environmental Resources Field Services Coordinator
1986 – 1987	Keystone Environmental Resources Environmental Field Technician

PUBLICATION

Radel, S.B., 1997. "How the EPA Can Make Brownfield Redevelopment a Success and Not Just Another Overused Environmental Catch-phrase." Paper published by the University of Baltimore Journal of Environmental Law, Volume 6, Fall 1997, No. 1.

ASSOCIATIONS

Pennsylvania Bar Association
Allegheny County Bar Association

ADDRESS

Steven B. Radel
118 Westminster Drive
Mars, Pennsylvania 16046
Daytime Phone: (412) 208-8863
Evening Phone: (724) 776-5302
Home Fax: (724) 776-7204

RICHARD B. RUCH, JR.
1519 Glenside Road
Downingtown, PA 19335
(610) 383-5811 (Home)
(610) 384-3926 (Fax)
e-mail:rbruch@voice.com

EDUCATION

M.S Meteorology, Pennsylvania State University (1975)
B.S. Meteorology/Air Pollution Control, Pennsylvania State University (1971)

EXPERIENCE

Vice President Project Director, Practice Leader of Air Quality Management, Roy F. Weston, Inc., West Chester, PA 1979-1997
Project Manager, Department Manager, Equitable Environmental Health, Inc., (formally Environmental Analysis, Inc.) Woodbury, NY 1972-1979
Research Assistance/Instructor/Consultant, Pennsylvania State University, 1969-1972
Weather Observer (Surface and Upper Air), Weather Forecaster. U.S. Navy, 1964-1968

FIELDS OF EXPERIENCE

Mr. Ruch has broad environmental management responsibilities with a special emphasis in the areas of air quality management. As National Practice Leader of the air quality management staff at WESTON, he was responsible for developing business/sales plans, coordinating proposal preparation, directing recruitment/staff development and served as guest lecturer/speaker at various seminars/workshops. As project director in the industrial business sector, he was also responsible for client development/maintenance and provided technical supervision/direction and regulatory interface in a variety of project assignments. His air quality expertise includes permitting, modeling, monitoring, emission/risk characterization and control system evaluations. He also managed or directed alternative fuels studies, site development/regulatory assessment studies, due-diligence/compliance audits, multi-pathway risk assessments, process safety/risk management planning, industrial hygiene studies, landfill gas recovery, stormwater management, spill prevention and sediment/erosion control plans and environmental data management. Mr. Ruch has also provided expert witness testimony and support as part of enforcement action or in civil litigation.

ENVIRONMENTAL PERMITTING

- Provided technical direction/supervision in the preparation of over two dozen RACT/Title V permit applications for a variety of manufacturing and energy-producing facilities.

- Involved in the implementation of MACT requirements, including start-up, shutdown and malfunctions plan for two (2) facilities.

- Directed or managed six comprehensive permitting projects including the reactivation of a petroleum refinery and bulk storage transfer facility and a new chemical plant/regional waste treatment facility. Obtained all local, state and federal environmental permits. Involved in presentations to the public and negotiations with regulatory authorities.

- Directed or managed the preparation of over 300 state air quality permits, including NSR/PSD permits and emission offsets for new/modified facilities located in every EPA region. Facilities included multi-fuel, fired boilers, pulp/paper mills, power plants, chemical processing plants, primary and secondary aluminum, gas turbines, furniture and glass manufacturing plants.

- Provided technical supervision and direction in developing and negotiating innovative permitting strategies for facilities with elevated emissions during start-up, shutdown and process recovery periods which provided greater operational flexibility under alternative operating permit conditions.

PROJECT DEVELOPMENT/REGULATORY ASSESSMENT

- Worked with numerous independent power producers and cogeneration companies in conducting siting studies regulatory reconnaissance surveys to identify any "fatal flaws" and a critical path schedule as part of the environmental permitting process.

- Coordinated and managed the evaluation of the environmental permitting and regulatory requirements as part of site development studies for three (3) different manufacturing facilities to be potentially located in six (6) different states.

- Provided technical direction/supervision in the siting and permitting of ten (10) waste to-energy facilities in seven (7) states.

RISK CHARACTERIZATION AND ASSESSMENT

- Directed the preparation environmental impact statement/health risk assessment for three (3) proposed hazardous waste incinerators.

- Supervised a comprehensive air quality impact assessment and ambient air/meteorological monitoring studies of two (2) pharmaceutical facilities in Ireland, including giving expert witness testimony in Irish High Court.

- Managed and directed an off-site consequence analysis exposure assessment for a specialty steel manufacturing facility. Demonstrated the need to evaluate downsizing tank storage and/or product substitution.

PRACTICE DEVELOPMENT/MANAGEMENT

- Over 18 years, developed a national air quality management practice of over 120 professionals with annual revenues in excess of $15 million.

- Coordinated the practice's strategic planning, proposal preparation, and staff recruiting/development.

- Invited speaker/presenter at a number of Clean Air Act workshops and seminars.

CLIENT DEVELOPMENT/MAINTENANCE

- As project director in the industrial business sector, responsible for developing key or targeted clients in the manufacturing segment.

- Developed and maintained a rage of clients, including Corning Incorporated, Carpenter Technology Corporation, Century Aluminum, East Penn Manufacturing, Atlantic Electric, Ogden Martin System and others.

- Have had annual sales averaging over 1.4 million dollars over the past three years.

CREDENTIALS/HONORS/PROFESSIONAL AFFILIATIONS

- Qualified Environmental Professional (No. 08970131)
- Chi Epstion Phi (Honorary Meteorology Fraternity)
- American Meteorological Society
- Air and Waste Management Association
- Pennsylvania Association of Environmental Professionals

LIST OF PUBLICATIONS

Ruch, R. B. Jr. and A. Serper, "Ambient Measurements of Asbestos in the Vicinity of Asbestos Sources," Proceedings of Fourth Joint Conference on Sensing of Environmental Pollutants. American Chemical Society, New Orleans, Louisiana (1977).

Serper, A. and R. B. Ruch, Jr., "Environmental Impacts of Resource Recovery Facilities Should Be Predetermined." *Solid Waste Management,* January-February, 1978.

Richard B. Ruch, Jr.
(Continued)

Smith, D. B. and R B. Ruch, Jr., "Comparative Performance in Complex Terrain of Several Air Quality Impact Assessment Models Based on Aerometric Program Data." Fourth Symposium on Turbulence, Diffusion, and Air Pollution, Reno, Nevada, 15-18 January, 1979. Published by the American Meteorological Society.

Ruch, R B. Jr., and D.J. Snyder, III, "Air Quality Considerations and Permit Requirements for Coal Cleaning Plants." Presented at Coal Conference and Expo V, Louisville, Kentucky, October, 1979.

Jones, K H., R. B. Ruch, J. B. Barone, J.F. Walsh, R. A. Karpovich. "The Rationale and Need to Consider Air Alternative to EKMA." APCA 33(4): 330-332, 1983.

Ruch, R. B. and R. M. Neu., "Air Pollution – The Rules Keep Changing." *Instruments and Control Systems,* 12 (12): 25-31, 1979.

Ruch, R. B. (Contributing Author), Standard Handbook of Plat Engineering, McGraw-Hill Book Company, 1983.

Ruch, R. B. and J. P. Marks, "Conducting an Environmental Assessment and Fatal Flaw Siting Analysis for Cogeneration Projects." Presented at Power-Gen "88, Orlando, Florida, December 1988.

Ruch, R. B. and J.S. Howell, "Proactive Industrial Strategies for the Clean Air Act Amendments of 1990". *Journal of Air and Waste Management Association.* 41(7): 922-927, 1991.

Karpovich, R. A., L. Militana, R. Ruch, J. Barone, "An Intermediate Terrain Atmospheric Dispersion Model." Proceeding of the 89th Annual AWMA Meeting, Vancouver, British Columbia, 16-21 June 1991.

Ruch, R. B. "Clean Air Act of 1990: Permitting and Air Toxics", Proceeding of Fourth Annual Environmental Affairs Compliance. American Foundrymen's Society, Inc., Milwaukee, Wisconsin, August 26-28, 1991.

Ruch, R. B. "Hidden Issues in Environmental Compliance," Proceedings of the Seventh Annual Cogeneration & Independent Power Market Conference. Sponsored by McGraw Hill's Independent Power Report Newsletter and Power Magazine, New Orleans, Louisiana, March 22-24, 1992.

Ruch, R. B. (Contributing Author), Standard Handbook of Plant Engineering (Second Edition) McGraw-Hill Book Company, 1995.

8

Proposal for Ported Batch Kiln Test Program for Harbor Rock for Conversation of Dredged Solids to Lightweight Aggregate

CONFIDENTIAL

BACKGROUND:

The development of new products and the improvement of existing products and processes are the Svedala Pyro Division's goals to meet changing customers needs in today's competitive market. To address these needs, Svedala operates the Process Research & Test Center (PRTC). The Process Research & Test Center is a fully-equipped facility with the capabilities to perform complex material and process testing and evaluations, as well as simulating a complete pilot flow sheet. The Test Center is unique in its ability to generate a complete flow sheet with many different unit operations, which can be assembled to represent a commercial plant. In addition, Svedala Industries process engineers are involved in the test work from batch feasibility studies and interpretation of pilot plant results to commercial equipment sizing, design, supply, installation and start-up.

The Process Research & Test Center is at the forefront of pyro technology for the division's worldwide leadership in developing energy-efficient, environmentally sound, and economic processes to extract and use the world's vital natural resources, including the recycling of waste products and destruction of hazardous materials.

Typical processes investigated in continuous pilot plant circuits include both rotary and fluid bed applications for drying, calcining, roasting, direct reduction, thermal conversion, soil decontamination and waste treatment.

In the last 40 years, the Process Research & Test Center has conducted over 50 major continuous pilot projects to simulate commercial operations for both private industry and government agencies.

Some of the materials that been subjected to pyro-processing at the Svedala Process Research and Test Center include:

Coal	Diatomite
Zinc Waste	Aluminum Hydroxide
Activated Char	Oil Shale
Kaolin	Tires
Paper Sludge	Limestone
Aluminum Dross	Iron Ore
Lightweight Aggregate	Waste Metals
Gold Ore	Foundry Sand

CONFIDENTIAL

OBJECTIVES:

The overall objective of the test program is to demonstrate that dredged material can be used to produce a commercial quality lightweight aggregate using commercially available equipment. The following items will also be determined as a result of the test program.

(1) That the LWA produced passes all applicable environmental (TCLP) for its intended uses.
(2) To quantify the mass & energy balance and emissions (air, water and solids) that will be generated in a full scale plant and to design the appropriate level of control required to meet applicable regulations.
(3) To determine the cost to design, procure, construct and operate a full scale plant.

EQUIPMENT:

The tests will be run in the ported batch kiln (PBK). Specifications for the ported batch kiln are shown on the attached data sheet. In addition the rotary dryer will be used to dry the material, the Abbe mill to grind the material, the fluid bed to calcine the material and the Bonnet extruder to make the ported batch kiln feed.

TEST PROGRAM:

Sample Preparation

(1) Receive ¾ yd3 (~1500 lb.) of wet dredge material
(2) Dewater the material by decanting the sample
(3) Save the water and have analyzed per Table I
(4) Perform physical and chemical analysis per Table I on "as-received material"
(5) Perform screen analysis on representative solids sample

Dry & Screen Solids

(6) Dry the solids in the rotary dryer
(7) Screen solids at 40 Mesh, store +40 Mesh fraction in a sealed container for subsequent analysis

Size Screened Solids

(8) Grind 40 x 100 Mesh fraction to –100 Mesh in Abbe mill
(9) Perform complete physical & chemical analysis per Table I on ground product

Test Material without Calcination

CONFIDENTIAL

(10) Extrude 80 lb of material in the Bonnet extruder
(11) Perform two firing tests in the ported batch kiln
(12) Characterize product bulk density, carbon content and quality

Test Calcined Material (if required)

(13) Calcine 200 lb of material
(14) Perform complete physical & chem. analysis of calcined material per Table I
(15) Extrude 80 lb. of material with oil addition
(16) Perform two firing tests in the ported batch kiln
(17) Characterize product bulk density, carbon content and quality

Test Uncalcined Material with Natural Shale (if required)

(18) Extrude 80 lb. of uncalcined material with natural shale
(19) Perform two firing tests in the ported batch kiln
(20) Characterize product bulk density, carbon content and quality

Confirmation

(21) Extrude 80 lb. of most desirable material
(22) Perform two PBK tests to confirm previous results
(23) Perform complete physical & chemical analysis per Table I

MATERIAL REQUIRED:

A Material Data Safety Sheet (MSDS) must be received at the Svedala Test Center before the material is shipped. All material both product and unused feed will be sent back to the customer at his expense.

REPORT:

The outline of the report is as follows: CONFIDENTIAL

Introduction

Conclusions: which will address the operating parameters, recommended temperatures, and assessment of the commercial operating conditions

Description: which will describe the test procedure and results.

Heat & Mass Balance: representative data from the test program will be used to prepare a heat & mass balance for a commercial scale kiln

Budgetary Estimate: a budgetary estimate will be made for a commercial scale plant along with estimates of the plant operating costs

Attachments: will include all of the test data collected, original analysis data and any thing else that concerns the test, such as pictures that are appropriate.

TEST COSTS:

- Sample Preparation
- Dry & Screen Solids
- Crush Oversize Solids
- Test Material without Calcination
- Test Calcined Material
- Test Uncalcined Material with Natural Shale
- Confirmation Tests

Svedala welcomes and encourages customer witnessing of the tests.

SAMPLE SHIPPING INSTRUCTIONS:

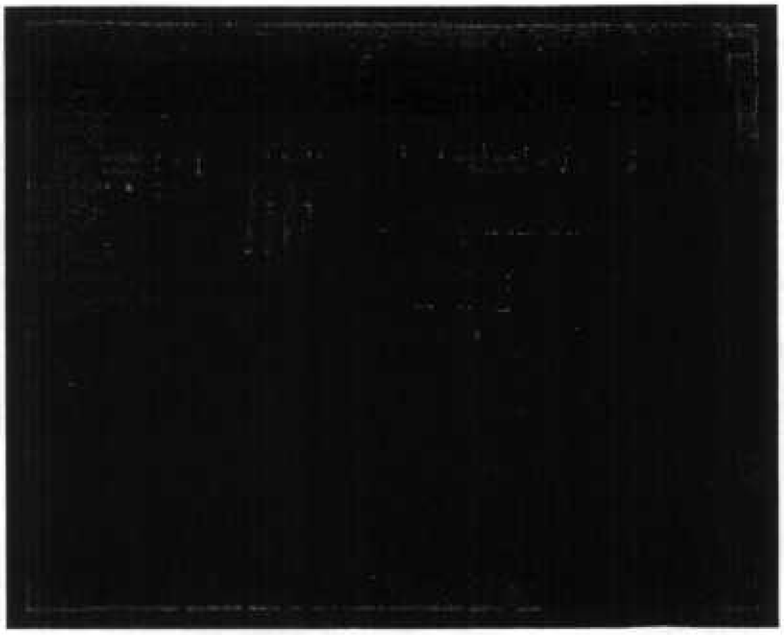
All samples should be shipped prepaid to our Test Center at the following address.

Svedala Industries
Process Research & Test Center
9180 5th Avenue
Oak Creek, WI 53154
Attn: Mike Weinecke

Tel: (414) 762-1190
Fax: (414) 764-3443

SVEDALA

PORTED BATCH KILN



SPECIFICATIONS

Dimensions:
- Diameter (inside refractory): 18 in.
- Length: 24 in.

Description:
- Natural gas burner with combustion chamber
- 8 rows of ports (44 total)
- Adjustable port on/off time
- 3 bed/overbed thermocouples (Type K)
- Variable speed drive
- Nitrogen cooled sampling probe

Options:
- Exhaust gas chamber
- Wet scrubber

Material Requirements:
@ 10% volumetric loading: 0.35 ft3

The ported batch kiln is used when a reaction between the material in the bed and a gas such as air, is required. For example, natural gas is used when the ports are underneath the bed to reduce iron oxide. Air is also used underbed to combust carbon in the bed of material. Air can also be added overbed to burn volatile matter released as a material is heated.

Batch rotary kilns are used to simulate the conditions in continuous commercial rotary kilns. Time in a batch kiln is equivalent to length in a continuous kiln. By controlling the gas temperature in the kiln, parallel or counter-current flow can be simulated. The combustion chamber is used to avoid direct flame impingement onto the bed of solids.

The batch kiln is refractory lined and natural gas fired. A multitude of ports allow gas to be injected under or over the bed or both. Temperatures of up to 1500 C can be used while maintaining the kiln atmosphere from highly oxidizing to highly reducing.

Solids and gas temperatures are measured by thermocouples at three locations within the kiln. These temperatures are continuously recorded. Solids samples may be withdrawn during a test using a nitrogen cooled sampler. This allows the solids chemistry to be "frozen" at the time the sample is taken.

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EXPERIENCE QUESTIONNAIRE

Submitted to: Maryland Port Administration, Office of Procurement
By: HarborRock Holdings
Information furnished in response to this Questionnaire and any verifications made by MPA shall provide a basis for determining the responsibility of bidders. In the event that references are deemed insufficient by MPA, the right is hereby reserved to determine respondent as not responsible which will cause the rejection of their bid.

1. How many years has your organization been in the business of as a consultant under your present name? Two years

2. List at least four customers, similar to the extent of work described herein, for which your organization has performed services similar to those requested herein.(Include company, address, contact person and phone number) Not applicable.

A. Later stage research and development company.

B.

C.

D.

2. How many people does your company presently employ on a;

A. Full time basis? One

B. Part time basis? Five

3. Has your organization performed any contract for any Department, Board, Administration, Agency, or organization of the State of Maryland over the last five (5) years? (Please list names, addresses, dates and the State employee responsible for accepting the work. No

4. Has your company or any of its officers ever been found guilty of any criminal act in regard to the performance of any contract by a federal, or state court or subjected to any penalty, or liquidated damages arising out of poor or nonperformance? Explain. No

5. Has your company ever been debarred bidding on future State Contracts by the Board of Public Works, or any other State or Federal organization for any reason? Explain. No

6. Has your company ever filed for bankruptcy/receivership or any other similar defalcation? Explain. No

The signatory of this form hereby affirms that the information as set forth is accurate, truthful and complete to his best knowledge and belief.

Dated this 31st day of March ~~1999~~ 2000

Name of Organization HarborRock Holdings

By: Richard E. Kimbrough

Title: Executive Vice-President- Strategic Planning

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SVEDALA

Mr. Jeff Otto
Harbor Rock
411 South Ivy Lane
Glen Mills, PA 19342

March 31, 2000

CONFIDENTIAL

Dear Mr. Otto,

With regard to the Maryland Port Authority Solicitation for Innovative Uses for Dredged Materials, Svedala is confident that if Phases 1 and 2 of the Test Program, as outlined by Svedala, are successfully completed that a commercial scale plant can be built without the need for pilot or demonstration scale plants. This confidence is based on Svedala's experience in scaling up processes from batch scale to commercial scale without any intermediate steps. Svedala has designed, built and successfully started 5 million tpy iron ore plants using only batch scale equipment. Svedala is currently offering a 100,000 tpy lightweight aggregate plant that was designed based only on batch kiln tests. This plant to be built in Scotland will process clay fines from a granite mining operation. In many respects, the clay from Scotland is similar to the dredged material.

After the successful completion of Phases 1 and 2, Svedala will be in the position to offer a commercial scale plant for the conversation of the dredged solids into lightweight aggregate. The plant capacity is limited only by the size of commercially available equipment. If higher plant capacities are required then multiple parallel lines would be used. Svedala's offering for a commercial scale plant will include warranties for important parameters such as capacity, product quality and air emissions.

Sincerely,

Bob Faulkner lyt

Bob Faulkner
Manager of Waste Systems
Svedala Industries Inc.

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